3F. RECREATION

SCOPE OF THE ANALYSIS

The scope of this recreation analysis is limited to the San Francisco Peaks and, in particular, to the Arizona Snowbowl SUP area.

EXISTING CONDITIONS

COMFORTABLE CARRYING CAPACITY

The 1979 Environmental Statement approved a CCC[164] of 2,825 skiers. While Snowbowl regularly exceeds this figure on good snow days, weekends and holidays, CCC at Snowbowl is currently limited by an uphill (i.e., lift) capacity of 1,880 guests and is ultimately limited by overall parking capacity. Snowbowl frequently experiences peak demand days, which significantly exceed the CCC of the existing facilities and infrastructure. Over the past 10 seasons, average peak day (i.e., holidays and good snow days) attendance has been approximately 3,434 guests.

WINTER RECREATION

Annual Visitation

With a current population of approximately 5.5 million, Arizona was the second fastest growing state in the nation throughout the 1990s. The greater Phoenix area[165] accounts for nearly two-thirds of Arizona's population.[166] Located approximately 150 miles due north of metropolitan Phoenix, Flagstaff is just over two hours driving time from a population base of roughly 3.3 million people. The greater Phoenix area is projected to grow at more than twice the national rate for the next several decades. By 2009, the greater Phoenix area population is projected to grow to 3.6 million (a 2.1 percent change); by 2025, it is projected to grow to approximately five million.[167]

In 2001/02, Snowbowl sold approximately 1,250 season passes. Eighty-four percent (1,050) of these passes were sold to Flagstaff area residents. The 2002/03 season saw roughly the same percentage of season passes sold, with 1,662 sold to Flagstaff residents and 214 sold to out-of-town residents (89 and 11 percent, respectively).

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[164] As indicated in Chapter 1, CCC is defined as the number of guests that can be comfortably accommodated by a ski area at any point in time. It provides for a pleasant recreational experience by not overburdening a ski area's facilities (including, but not limited to, parking, restaurant seating, restrooms, and uphill/downhill capacity). CCC is utilized by ski area planners and the Forest Service as a planning tool and *does not constitute a cap on visitation*. Facilities are typically designed to accommodate 125 percent of a ski area's CCC in order to preserve the guest experience on peak visitation days, which are anticipated periodically throughout the season.

[165] The greater Phoenix area is defined primarily as Maricopa County, which includes (but is not limited to) the following cities: Phoenix, Scottsdale, Tempe, Mesa, Peoria, Surprise, El Mirage, Glendale, Goodyear, Buckeye, Tolleson, Avondale, Gilbert and Chandler.

[166] Greater Phoenix Economic Council, 2003

[167] Id.

Because Snowbowl has no snowmaking capabilities, the ski area's operations, and therefore financial viability, are 100 percent dependent on natural snowfall, and seasonal visitation fluctuates considerably from year-to-year. Table 3F-1 compares annual snowfall with days of operation and skier visitation for the past 22 seasons at Snowbowl.

Table 3F-1
Comparison of Annual Snowfall, Days Open and Visitation at Snowbowl

Season	Snowfall (Inches)	# of Days Open	# of Visits
1981/82	265	123	63,000
1982/83	276	135	99,626
1983/84	76	64	28,913
1984/85	266	118	114,707
1985/86	210	124	105,252
1986/87	290	112	125,026
1987/88	182	92	119,259
1988/89	170	79	120,132
1989/90	240	74	99,280
1990/91	233	112	106,000
1991/92	360	134	173,000
1992/93	460	130	181,000
1993/94	220	114	116,388
1994/95	259	122	176,778
1995/96	113	25	20,312
1996/97	270	109	153,176
1997/98	330	115	173,962
1998/99	150	60	35,205
1999/00	180	45	66,152
2000/01	272	138	162,175
2001/02	87	4	2,857
2002/03	206	96	88,000

Figure 1-2, displayed in Chapter 1, provides a graphical representation of annual skier visitation and total annual snowfall from 1981 through 2003. A statistical analysis of the 22 seasons of data clearly indicates there is strong relationship between the two variables with a correlation of 0.796, indicating that annual snowfall is a useful statistic in predicting skier visitation 79.6 percent of the time.

Terrain Overview

Approximately 2,300 feet of elevation difference exists between the top terminal of the Agassiz Chairlift and Hart Prairie. Snowbowl's existing terrain network is comprised of 32 developed trails on approximately 139 acres. However, additional skiable terrain in the form of natural, non-maintained glades (i.e., tree skiing) and chutes are available within the SUP area outside of the formal trail network. A terrain park (open to snowboarders and skiers) is located on *Sunset Boulevard* (trail #10).

The Hart Prairie area is dominated by gentle terrain that is suitable for beginner level guests. The lower mountain in the vicinity of the Sunset Chairlift and *Fort Valley Glade* is predominantly intermediate level terrain with small pockets of steeper, expert terrain and gentler beginner terrain. The upper portions of the mountain are dominated by expert terrain with areas of intermediate terrain scattered throughout. The higher elevation terrain on the northern aspect of the SUP area is steep, but becomes more gradual in the lower elevations.

Skier ability levels at Snowbowl, and the percentages of overall terrain comprising each ability level, are provided in Table 3F-2.

Table 3F-2
Terrain Ability Levels

Ability Level	Percent of Snowbowl's Existing Terrain	Industry Norm (Percent of Total Terrain)	Difference
Beginner	1	5	-4
Novice	44	15	+29
Low-Intermediate	25	25	0
Intermediate	22	35	-13
Advanced-Intermediate	6	15	-9
Expert	2	5	-3

As indicated in Table 3F-2, the Snowbowl exhibits a large surplus of novice level terrain with demonstrated shortages of beginner, intermediate, advanced-intermediate, and expert terrain.

Lift Network

Snowbowl's lift-accessed terrain is served by four aerial chairlifts and one beginner surface lift. Existing lift specifications are provided in Table 3F-3.

Table 3F-3
Existing Lift Network

Lift	Slope Length (feet)	Vertical Rise (feet)	Design Capacity (persons/hour)	Daily Lift Capacity (guests)
Agassiz Mid	4,794	1,296	810	480
Agassiz Top	6,475	1,973	270	200
Hart-Prairie	3,217	658	966	550
Sunset	2,677	637	1,350	460
Aspen	1,591	242	554	170
Little Spruce	302	35	200	20
Total			***4,150***	***1,880***

Terrain Density Analysis

In order to achieve a balanced recreational experience, the uphill (lift) capacity of a ski area should be balanced with its downhill (terrain) capacity. As the difficulty of the terrain increases, the acceptable skier density (skiers per acre) decreases.

Table 3F-4 presents a terrain density analysis displaying the existing terrain at Snowbowl using an industry accepted density in terms of guests per acre. The Density Index expresses the Actual Density over the Target Density as a percentage.

Table 3F-4
Terrain Density Analysis (Existing)

Lift	Daily Lift Capacity	Terrain Area (acres)	Actual Terrain Density (guest/acre)	Target Trail Density (guest/acre)[a]	Difference	Density Index
Agassiz Top	480	57.5	2	11	-9	18%
Agassiz Mid	200	14.8	4	7	-3	57%
Hart Prairie	550	26.4	6	18	-12	33%
Sunset	460	21.4	5	11	-6	45%
Aspen	170	18.1	4	18	-14	22%
Little Spruce	20	0.5	8	30	-22	27%
Total	***1,880***	***138.6***	***4****	***13****	***-9****	***32%****

[a] While no published industry standards exist, this is considered a norm throughout the industry as based on guest expectations.
* Weighted average.

Extremely high or low actual terrain densities (in comparison to the target) can be evidence of improperly balanced uphill and downhill capacities. The Actual Terrain Density and Density Index columns in Table 3F-4 indicate that, *at a CCC of 1,880*, Snowbowl has very low terrain densities, and that the current lift capacity is insufficient to accommodate the existing terrain, resulting in underutilized terrain.[168] Therefore, at Snowbowl's existing CCC of 1,880 guests, one would typically encounter relatively uncongested ski trails and at-capacity lifts.

However, as previously mentioned, peak days frequently result in visitation well in excess of Snowbowl's existing CCC (approaching 3,400 skiers). Therefore, a terrain density analysis was conducted for peak capacity days in which crowds of 3,400 guests are experienced. This terrain density analysis indicates that increased attendance does not directly relate to increased terrain densities. While lift line waiting times currently become unacceptably long at 3,400 skiers (lines at more popular lifts such as Agassiz and Little Spruce can exceed 40 minutes) skier densities on Snowbowl's terrain increase only slightly.

[168] An inherent fault of the model used to calculate terrain densities is that it assumes a mathematical uniformity to the distribution of skiers across all available terrain which, in actuality, is not the case. This model cannot account for areas such as major collector trails which receive extremely high use and frequently experience unacceptably high skier densities.

Fall Line Analysis

A fall line represents the path an object would take as it descends a slope under the natural influence of gravity (e.g., a ball rolling downhill). A fall line analysis is useful in ski area planning, as it indicates the natural flow of skiers as they descend through terrain to lower elevations and eventually to lift terminals and/or the base area. Thus consistent fall lines throughout a ski area provide for the best recreational experience and result in lesser ground disturbance due to a reduced need for terrain modification associated with trail construction. An analysis conducted at Snowbowl indicates that both developed and undeveloped terrain throughout the SUP area exhibits consistent fall lines that are appropriate for skiing.

Slope Aspect Analysis

The results of the slope aspect analysis within the Snowbowl SUP area indicate that the majority of the developed terrain faces north/northwest, which provides for minimal sun exposure, optimal retention of snow, and therefore favorable skiing conditions. The exception is the Hart Prairie area, as it is oriented to the west, which detracts from snow conditions with late morning/early afternoon sun exposure.

Snowplay

While in the past, snow on the San Francisco Peaks brought large crowds to NFS lands to snowplay (defined as sledding, tubing, saucering, building snowmen, etc.); this activity is not permitted within the Snowbowl SUP area, nor is it now allowed along the Snowbowl Road. Prior to the 2002/03 winter season, the general public was attracted to the areas along the Snowbowl Road for dispersed snowplay activities. These activities created ongoing public safety issues including: snow sliding on non-directional equipment (sleds, saucers and trash bags) in wooded or steep areas, sometimes across heavy traffic on Snowbowl Road, pedestrian/vehicular encounters, sanitation and refuse concerns, conflicts with Native American traditional ceremonies and gathering, and difficulties for emergency vehicles passing through congested areas. During periods of abundant snow as many as 300 vehicles per day may have been parked along the Snowbowl Road belonging to visitors engaged in dispersed snowplay activities. Beginning with the 2002/03 winter season, the Forest Service has prohibited parking along the Snowbowl Road and initiated an active enforcement program. Although signs have been posted at the bottom of the Snowbowl Road informing visitors that snowplay is not allowed, scores of cars continue to drive up the road in search of snowplay opportunities. The majority of these visitors reach the Snowbowl base area only to be turned back by the ski area parking staff. On a peak day with good snow conditions, the Snowbowl parking staff may turn away as many as 500 cars full of visitors seeking an opportunity to play in the snow. Unable to consistently discern skiing guests from snowplay visitors, the Snowbowl staff frequently is required to ask visitors found snowplaying in and adjacent to the parking areas and on the ski trails to leave. This creates an unfortunate and contentious situation for all involved.

The Wing Mountain Cinder Pit (approximately three miles north of Snowbowl Road on Highway 180) and the Crowley area (approximately one mile past the Flagstaff Nordic Center on Highway 180) also offer dispersed snowplay activities. However, given the relatively low elevation of these sites, they rarely offer the necessary snow conditions to provide an adequate snowplay experience, particularly early in the season when snow is only present at higher elevations.

Summer Recreation

Summer Events

Events such as concerts, weddings and festivals are held throughout the summer season. These events are reviewed and approved on a case-by-case basis via Snowbowl's annual summer operating plan.

Hiking within the SUP Area

Currently, demand for developed hiking trails within the SUP area far exceeds opportunity. While visitors may choose to hike both on and off roads/trails in the lower portions of the SUP area, due to the steep, loose nature of Snowbowl's terrain, no hiking trails or roads currently exist to accommodate hiking above the Agassiz Lift's mid-station. One exception is a short walking path leading from the Agassiz Lift's top terminal to an observation deck. Hiking is not allowed above the observation area to protect critical habitat for the San Francisco Peaks groundsel, fragile tundra and important Native American religious sites. While hikers who start out at the base area may explore the entire SUP area as they choose, summer visitors riding the Agassiz Chairlift (described below) are required to ride it back down.

Summer Sky Ride

The Summer Scenic Sky Ride at the Snowbowl transports guests to the top of the ski area via the Agassiz Chairlift (11,500 feet in elevation). Approximately 30,000 visitors utilize the summer Scenic Sky Ride annually between Memorial Day and Labor Day. From this elevation, over 70 miles of the northern Arizona landscape can be viewed, including the Grand Canyon and downtown Flagstaff. Minimal hiking opportunities are available at the top of the Agassiz Chairlift in order to protect the fragile alpine tundra and endangered plants. A short path leads to an observation deck. Guests are prohibited from hiking down to the base area due to the absence of formal hiking trails within the upper limits of the SUP area. A Forest Service interpretive specialist is typically available to answer any questions regarding the biology, tundra, Native American cultural values and uses, threatened and endangered species and geology of the region.

Kachina Peaks Wilderness

The Snowbowl SUP boundary is bordered on the north, south and east by the Kachina Peaks Wilderness Area, which was designated by Congress in 1984. This 18,960-acre Wilderness area encompasses most of the upper reaches of the San Francisco Peaks, including Humphreys Peak, Arizona's highest point at 12,643 feet elevation. The area is named for the Hopi gods who are said to inhabit the Peaks.

Two hiking trails offer access to the Wilderness from the SUP area. The Humphreys Peaks Trail (No. 151) leads to the top of the Peaks, which form the rim of the Peaks' inner basin – a caldera which was formed during the Peaks' most recent volcanic eruption. That crater now supports a stand of white barked aspens and mixed conifers. The Kachina Trail (No. 150) offers access to the forest and meadows on the Peaks' lower slopes south of the SUP area. Considering the relatively small size of this Wilderness area, its proximity to Flagstaff and large metropolitan areas, the high use of the designated wilderness for most types of non-motorized recreation activities, and the fact that the ski area is surrounded on three sides by Wilderness, the Forest Service faces significant management challenges for both the Wilderness and the ski area for their intended values and objectives. Additionally, the Humphreys Peak Trail, originating from the SUP area, but located almost entirely within the Wilderness, is the highest use Forest Service system trail in the Flagstaff area, often receiving up to 400 hikers per day on holidays such as July 4th, and up to one hundred hikers per day on a typical summer mid-week day. Because Snowbowl's SUP area pre-dates the establishment of the Wilderness, the Forest Service manages the ski area in a way that allows activities typically permitted at other ski areas, but with as much consideration for impacts upon wilderness as is reasonable.

Camping is not allowed above timberline at 11,000 feet in elevation or within the Inner Basin. Hikers are also urged to stay in designated trails at this elevation. These restrictions are in place to help protect the fragile tundra, the threatened San Francisco Peaks groundsel (*Senecio Franciscanus*), Native American religious sites and concerns, and the City of Flagstaff's municipal water supply within the Inner Basin.[169]

Wilderness Trailhead Access

Trailhead parking and access to the Kachina Peaks Wilderness is available in the ski area's lower parking lots; day and over night parking is available for the Humphreys Trail in lots 8 and 9, and for the Kachina Trail in lot 6. Parking for Wilderness users in the Snowbowl's parking lots is available all summer and on weekdays during the winter. Parking on the Snowbowl Road is prohibited.

Winter Wilderness Permits and Use

In 1998, the Forest Service instituted a winter permit system for access to the Wilderness from the SUP area. Individual permits are free, and are required to be carried when a person enters the Wilderness from the SUP area; permit holders are required to register each time the Wilderness is accessed through the ski area. The purpose of the permit system is to promote safety, education and awareness of the hazards and responsibilities necessary for backcountry travel, not to restrict access. This is a result of numerous search and rescue efforts in recent years for poorly prepared people leaving the SUP area, and the resultant searches, injuries and fatalities from avalanches and cold weather. All backcountry travelers are held accountable for search and rescue efforts should they become necessary. Violators of this permit system are cited and fined.

Registration boxes are located within the SUP area at the Hart Prairie Lodge ticket windows and at the top of the Agassiz Chairlift.[170] Persons accessing the Wilderness overnight or for a period of time exceeding Snowbowl's operating hours are required to

[169] The Peaks' caldera, known as the Inner Basin, contains an aquifer that supplies part of the municipal water for the City of Flagstaff, the largest city on the Colorado Plateau. Water is piped southward to the city from a series of wells tapping the basin's aquifer, which is recharged by seasonal snowmelt.

[170] Wilderness users are allowed to exit the ski area boundary atop the Agassiz Chairlift during winter months only.

leave a copy of their permit in the windshield of their vehicle. Approximately 80 percent of visitors are assumed to register at the Wilderness registration boxes.

Forest Service-issued annual permits for winter-time access to the Kachina Peaks Wilderness during the last five seasons are provided in Table 3F-5.

Table 3F-5
Kachina Peaks Wilderness Permits

Year	Number of Permits Issued
1998/99	119
1999/00	138
2000/01	219
2001/02	44[a]
2002/03	384

[a]The CNF was closed to entry due to extreme fire hazard during a portion of this period.
Source: USDA Forest Service, 2002a.

Trail visitor numbers are calculated from trail registration boxes at each trail. Winter Wilderness use (between January and March) is approximately 10 percent of summer visitation. The information contained in Table 3F-6 was gathered from May 1998 to December 2000.

Table 3F-6
Kachina Peaks Wilderness Utilization

Humphreys Trail	
2003	13,242 visitors
2002	8,686 visitors (0 recorded June)
2001	11,560 visitors (0 recorded January, February, or March)
2000	8,172 visitors (0 recorded in November or December)
1999	13,495 visitors (0 recorded January or February)
1998	13,735 visitors (0 recorded in January, February, March, April, May, or November)
Kachina Trail	
2003	5,512 visitors
2002	3,902 visitors (0 recorded in January, February, March, April, or June)
2001	5,090 visitors (0 recorded in November or December)
2000	4,813 visitors (0 recorded in March)
1999	5,062 visitors (0 recorded in January, February, March, or April)
1998	4,474 visitors (0 recorded in January, February, March, April, November, December)
Weatherford Trail	
2003	1,732 visitors
2002	687 visitors (0 recorded between January and April, or June)
2001	1,842 visitors (0 recorded February, March, November, or December)
2000	1,272 visitors
1999	1,198 visitors (0 recorded between January and April)
1998	1,129 visitors (0 recorded between January and April, November, and December)
Bear Jaw/Abineau Trail	
2003	1,837 visitors
2002	805 visitors (0 recorded February, March, or September)
2001	2,022 visitors (0 recorded in February, November, or December)
2000	2,296 visitors (0 recorded in November or December)
1999	1,325 visitors (0 recorded between January and April)
1998	1,126 visitors (0 recorded between January and May, November, or December)
Total Annual Use of Kachina Peaks Wilderness Trails	
2003	22,323
2002	14,080[a]
2001	20,514
2000	16,553[a]
1999	21,080
1998	20,464

[a]The CNF was closed to entry due to extreme fire hazard during a portion of this period.
Source: USDA Forest Service, 2003a.

ENVIRONMENTAL CONSEQUENCES

DIRECT AND INDIRECT EFFECTS

Two issues were raised pertaining to recreation. These issues will be addressed separately.

Recreational Opportunities

Issue:

The effects of the Proposed Action on the quality, distribution, and opportunity for winter and summer recreational experiences within the SUP area.

Indicator:

Comparison of Historic Annual Winter and Summer Recreation Visitation Versus Those Anticipated Under Various Alternatives.

Alternative 1 – No Action

Under Alternative 1, Snowbowl's CCC would remain at 1,880 guests. No improvements to ski area infrastructure or terrain would be approved under this alternative, and therefore the summer and winter recreational experience would be expected to remain unchanged under this alternative

As Snowbowl's recent climatic history exhibits (reference Table 3F-1 – Visitation and Snowfall), visitation trends at the ski area would continue to be defined by natural snowfall under the No Action Alternative. Average *peak day* attendance would be anticipated to resemble historic trends - approximately 3,400 guests on a handful holidays and good snow days each year. Generally speaking, future annual visitation levels under the No Action Alternative would be expected to resemble historic visitation, with slight increases attributable to regional population growth.

In making visitation projections under the No Action Alternative, it is essential to note that major fluctuations would be expected from year-to-year. The historic record of the past 24 seasons shows that year-to-year totals vary as much as –97 percent to +71 percent from the median. Annual visitation could be expected to fluctuate from roughly 98,000 to 110,000 between year 0 (the first year following selection of the No Action Alternative) and year 11.[171] The summer Ski Ride program would be expected to continue to draw approximately 30,000 visitors each year under the No Action Alternative.

Alternative 2 – The Proposed Action

By increasing guest capacities at the day lodges, chairlifts, terrain and other ski area infrastructure, the CCC of the Snowbowl would increase to 2,825 guests-at-one-time, without substantially increasing the current capacity of skier parking. While this increase would not constitute a change in peak day attendance, it would allow the ski area to better accommodate current use levels. With the increased CCC, busy holiday and snow day

[171] Barring any unforeseen climatic or economic conditions that would inordinately effect visitation.

crowds that currently overburden the ski area's infrastructure would be more comfortably accommodated resulting in an improved visitor experience.

While average peak day attendance levels are not anticipated to increase under the Proposed Action, the frequency of these peak days is anticipated to increase across the course of the winter season. Therefore, total annual visitation associated with skiing would be projected to increase considerably under the Proposed Action, as attributable to a more consistent snow pack due to the installation of snowmaking, increased lift capacity, increased terrain, and a small increase in parking. Year-to-year variability in visitation under the Proposed Action would be expected to be much less under the Proposed Action, approximately +/- 15 percent. With implementation of the Proposed Action, annual visitation levels could be expected to increase from roughly 98,000 in year 0 to around 215,000 by year 11.

The snowtubing facility would be expected to attract a new market for wintertime recreation, helping meet existing demand, as well as provide an additional amenity for Snowbowl's existing clientele. The snowtubing facility has been designed with a CCC of 600 tubers-at-one-time; this figure, along with an accompanying parking area, is independent of Snowbowl's proposed on-mountain CCC of 2,825. However, it is assumed that the snowtubing facility would only approach full capacity on weekends and during holiday periods. The snowtubing facility's annual contribution to additional wintertime attendance at Snowbowl has been projected to fluctuate from roughly 34,000 and 42,000 between year 0 and year 12. Peak day tubing usage could approach as many as 1,680 guests.[172]

The installation of a hiking trail linking Agassiz Lodge with the top of the Agassiz Chairlift, thereby enabling guests to hike between the top of the Agassiz Chairlift and the base area, is not anticipated to substantially increase summertime guest attendance. This hiking trail is intended to accommodate existing demand for hiking opportunities within the SUP area, and is not anticipated to substantially increase summer visitation. This trail may serve the purpose of providing an alternate hiking experience for people who would have hiked the crowded Humphreys Peak Trail, thereby removing some of the heavy pressure on that trail. Additionally, a slight increase in non-Sky Ride related hiking use of the new FS system trail may result. Summertime attendance on the Sky Ride could reasonably be expected to increase slightly as a result of this new hiking opportunity as people take advantage of riding uphill and associated hiking downhill. Overall use, however, would not be expected to increase substantially, and would likely hover in the neighborhood of 30,000 visitors annually.

Alternative 3

As detailed within the Social and Economic Resources section (Section E), the certainty of the development of the facilities included within Alternative 3 is financially unclear. Given the wide variability in visitation as a function of natural snowfall, the owners of the Snowbowl may not be able or willing to invest the funds necessary to capitalize the Alternative 3 improvements. Likely, a portion of the Alternative 3 improvements - those requiring smaller investments – would be developed. For the purposes of comparison,

[172] Assuming four, two-hour sessions per day at a 70 percent utilization rate.

this section provides estimated changes in annual visitation assuming *all* of the Alternative 3 improvements would be implemented.

Under Alternative 3, wintertime attendance is anticipated to increase slightly above the No Action Alternative, but below that of the Proposed Action. Alternative 3 does not include snowmaking or installation of the snowtubing facility – the two components of the Proposed Action that would be expected to generate the bulk of additional wintertime visitation. Therefore, projected annual visitation would be significantly constrained by continued unreliability of snow cover and expectations regarding days open per season. However, the small increases in projected annual visitation in Alternative 3 are attributable to regional population growth (as in the No Action Alternative), construction of the Humphreys Pod (additional lift capacity and terrain), small additions to parking, as well as trail grading projects that exceed those prescribed in the Proposed Action. More intense trail grading in strategic areas are designed to allow Snowbowl to open trails under reduced natural snow conditions, and thereby would be expected to contribute to incremental increases in annual visitation (assuming adequate natural snowfall) as compared to the No Action Alternative.

Essentially the same year-to-year fluctuations in visitation as presented in the No Action Alternative remain for Alternative 3. Alternative 3 could be expected to produce annual skier visitation levels between 98,000 and 118,000 between year 0 and year 11.

Indicator:

Narrative Description of the Quality Of Winter and Summer Recreational Opportunities Under All Alternatives.

Alternative 1 – No Action

Under the No Action Alternative, no operational or infrastructural changes/additions would occur within Snowbowl's SUP that would improve the recreational experience. Generally speaking, the quality of wintertime recreation opportunities under the No Action Alternative would continue to be dictated by the amount of natural snowfall throughout each season. As indicated in Table 3F-1, natural snowfall is widely variable, meaning that Snowbowl would continue to offer an undependable winter recreational experience.

In lieu of updating guest service facilities at Snowbowl, selection of the No Action Alternative would translate to a continuation of crowded, and sometimes undesirable guest experiences in many areas, such as in the lodges and on the chairlifts. As mentioned previously, Snowbowl would be expected to continue to experience peak demand days under the No Action Alternative, which significantly exceed the current CCC of the existing facilities, lifts and terrain. The public's demand for intermediate and beginner terrain would go unmet on peak visitation days, resulting in significant over use of the existing terrain and therefore high densities.

As described within the Existing Conditions section, a demonstrated demand exists for dispersed snowplay activities. Under the No Action Alternative, the Snowbowl Road would remain closed to parking – and therefore snowplay activities along the road. Despite efforts to inform the public of the parking and snowplay prohibitions, it is anticipated that numerous visitors would continue to drive up the Snowbowl Road only to be turned away by the parking staff.

As detailed within the Social and Economic Resources section (Section E), the Snowbowl operates in a capital-intensive business, where capital expenditures are required on a regular basis to maintain the quality of the recreational product, offer an adequate level of guest service, and to maintain a reasonable level of competitiveness with other ski areas. Over the past eleven operating years, the Snowbowl has invested a cumulative total of $4.42 million in capital expenditures, all of which has been oriented toward ski area maintenance.[173] Within the ski industry, it is generally assumed that at least six percent of gross revenues should be allocated for maintenance capital – capital expenditures sufficient to maintain a ski area at an acceptable level of quality, but not to make significant improvements to the facility. The Snowbowl's capital investment over the past eleven years has equaled 8.87 percent of gross revenues.[174] However, this level of expenditure has required the ski area owners to infuse additional capital as these expenditures have exceeded net revenues. Under the No Action Alternative, it is probable that the owners of the Snowbowl would be unable or unwilling to continue to infuse the recurring capital necessary to maintain the quality and service level currently offered.

While no changes would occur to the recreational experience under the No Action Alternative, it is probable that Snowbowl's existing and potential clientele would be effected in terms of the forgone recreational opportunities derived from improved (or at least minimally maintained) facilities, and increased snowpack consistency that are associated with the Proposed Action.

Alternative 2 – The Proposed Action

Under the Proposed Action, all effects to the quality of the recreational opportunities within the SUP (summer and winter) would be positive in nature.

Winter Recreation

Lifts and Terrain

Under the Proposed Action, the only aerial lift at Snowbowl that would remain unchanged is Agassiz. The remaining three lifts in the existing lift network would be realigned and/or upgraded. Two of the upgraded lifts (Sunset and Hart Prairie) would utilize high-speed, detachable-chair technology. The upgraded lift network would also be complimented by the installation of the Humphreys Chairlift (likely utilizing the Sunset Chairlift after its replacement). Three beginner surface lifts would be added to improve Snowbowl's teaching opportunities in the Hart Prairie area. In addition, the proposed terrain park would specifically be serviced by a surface lift. Combined, the upgrades and

[173] The Snowbowl's capital expenditures have been oriented toward maintenance of the current level of quality, including items such as restrooms, snow grooming equipment, reconstructed or new ski runs, water trucks, and background infrastructure. Capital investment has not been sufficient to add improvements that would be evident to the skier, such as new lifts, lodge space, terrain, etc.

[174] 11 year Gross Revenues = $49.78 million. 11 Year Capital Expenditures = $4.42 million (8.8 percent of Gross Revenues).

additions to Snowbowl's surface and aerial lift network would improve the recreational experience for guests of all levels by improving the balance between uphill and downhill capacities.

As indicated, Snowbowl lacks intermediate and advanced intermediate terrain. With selection of the Proposed Action, Snowbowl's developed terrain network would increase from approximately 139 acres to approximately 204 acres (a 47 percent increase). The nature of the developed terrain additions would primarily benefit Snowbowl's intermediate guests, with approximately 52 acres of additional intermediate terrain proposed. Beginner-level guests would gain approximately 13.5 acres of new terrain, and advanced skiers would gain roughly eight acres of developed terrain. The additional 47 acres of improved glades would enhance the skiing experience for Snowbowl's advanced and expert clientele. In total, the quality of the recreation experience at Snowbowl would improve as a result of these lift and terrain upgrades.

Consistent Snowpack

The public scoping period (which included mailings, public meetings, and media coverage) produced approximately 1,020 responses, of which approximately 65 percent were in favor of the Proposed Action as presented. While the Forest Service NEPA process is clearly not intended to be a "voting" process, this indicates considerable support for the primary component of the Proposed Action – snowmaking. It is apparent that Snowbowl's clientele considers snowmaking to be integral to the betterment of the ski area's recreational experience.

While the proposed snowmaking system would not rule out all natural variables (i.e., snowmaking technology is highly dependent on ambient air temperatures to be successful), it is designed to provide a consistent snowpack each season from roughly mid/late November through late March/early April. A consistent snowpack from season-to-season would help redefine the Snowbowl as a permanent and reliable winter sports facility in Northern Arizona's recreational setting. It is probable that this redefinition would reduce Arizonans traveling beyond the state (into the Four Corners area) in search of better, more consistent snow conditions.

Terrain Density Analysis

As a component of this analysis, a terrain density analysis was performed for the proposed additions and increased CCC of 2,825.

Table 3F-7
Terrain Density Analysis (Proposed Action)

Lift	Daily Lift Capacity	Terrain Area (acres)	Actual Terrain Density (guest/acre)	Target Trail Density (guest/acre)	Difference	Density Index
Agassiz/C-3	650	43.5	5	8	-3	63%
Hart-Prairie/DC-4 (New)	660	31.0	10	17	-7	59%
Sunset/DC-4 (New)	690	82.7	3	10	-7	30%
Aspen/C-2	160	16.2	3	18	-15	17%
Humphreys/C-3 (New)	470	27.2	5	6	-1	83%
Carpet 1	80	1.0	19	18	1	106%
Carpet 2	80	1.0	19	18	1	106%
Half Pipe	35	1.5	7	12	-5	59%
Total	**2,825**	**204.2**	**6***	**11***	**-5***	**56%***

* Weighted Average.

As compared to Table 3F-4, Table 3F-7 indicates that the uphill (i.e., lift) and downhill (i.e., trail) capacities are better balanced under the Proposed Action than under the existing condition. Even with a higher CCC, the additional terrain made available under the Proposed Action better disperses guests across the SUP area. Therefore the terrain/infrastructural upgrades and increased CCC under the Proposed Action would improve the Snowbowl's ability to accommodate the existing levels of visitation. Skier densities would remain within the industry norm while lift line waiting periods would decrease.

Slope Aspect Analysis

The results of the slope aspect analysis conducted for existing terrain within the SUP area are provided in the Existing Conditions section. The majority of the proposed terrain additions are aligned in north/northwest aspects (which provide for optimal retention of snow). However, the terrain additions related to the development of the Humphreys Chairlift are not. A detailed slope aspect analysis was completed specific to the approximately 31 acres of skiing trails proposed within the Humphreys pod. The aspect of these trails averages 238.9 degrees azimuth, which would be characterized as a southwest-west slope aspect. The majority of the terrain (93.4 percent) lies southwest (180 to 270 degrees azimuth) with the remainder (6.6 percent) facing west to northwest (270 to 337 degrees azimuth).

While the Humphreys pod does not offer an optimal slope aspect, operations at other western ski areas – at similar elevations – has demonstrated that this can be effectively overcome through the installation of snowmaking infrastructure and through a concerted effort in maintaining adequate coverage in this pod. Additionally, the ski trails have been specifically designed in a mosaic of open spaces with the intent of maximizing the shading potential of the existing tree canopy. Through a combination of snowmaking, natural shading, and effective snow management, it is anticipated that the skiing terrain within the Humphreys area would provide an acceptable skiing product throughout the majority of Snowbowl's operating season.

Snowplay

The proposed lift-served, developed snowplay area in Hart Prairie would help fulfill the ongoing demand for alternative winter recreation activities on the CNF. As detailed within the Existing Conditions section, the areas along the Snowbowl Road were recently closed to parking in an effort to manage ongoing issues stemming from dispersed snowplay activities. The proposed snowplay facility would offer an additional attraction for non-skiers who normally would not utilize or visit the ski area or perhaps lack the physical abilities to ski. In addition, the snowplay facility would benefit Snowbowl's existing clientele, as another option for recreation while utilizing the ski area's facilities. The professionally designed/maintained snowtubing area would provide a safe and organized alternative to dispersed snowplay activities that currently occur on NFS lands along the Snowbowl Road and elsewhere on the CNF.

Half Pipe

The half pipe, proposed for construction near the Sunset Lift, would add a currently unavailable but needed element to Snowbowl's alternative terrain features. The half pipe would benefit snowboarders and skiers alike, and would be specifically served by a surface lift. With much of Snowbowl's use coming from snowboarders, and considering the popularity of such terrain features, this would be an attractive addition to the ski area.

Upgraded Guest Services

Upgrading the ski area's uphill capacity (and therefore CCC) would necessitate making commensurate improvements to ski area-wide infrastructure and guest service facilities.[175] By increasing and updating Snowbowl's guest service facilities at Agassiz Lodge and Hart Prairie Lodge, a Native American cultural and education center, and new ski team buildings, the overall recreational experience would be improved (e.g., food service seating would be increased eliminating the need for guests to sit on the floor).

In addition to the capital investments necessary to develop the proposed facilities, the Proposed Action would allow the business to continue to invest the recurring maintenance capital necessary to maintain the quality and level of service offered to the guest.

Summertime Recreation

Hiking

The proposed hiking trail from Agassiz Lodge to the top of the Agassiz Chairlift would add a new element to Snowbowl's summertime recreational offerings. The trail would enable guests to hike down to the base area after utilizing the Sky Ride program. Approximately 30 percent of guests participating in the summer Sky Ride express an interest in being allowed to hike off the mountain rather than ride the lift down.

[175] Infrastructure, utilities and guest services are further detailed in Section G.

Additionally, the opportunity to hike from the bottom of the ski area to the top of Agassiz Chairlift is expected to be highly valued.

Alternative 3

From a recreational perspective, Alternative 3 does not include the primary elements associated with the Proposed Action which would most affect the overall recreational experience. Without snowmaking and snowtubing, the overall recreation experience at Snowbowl would be less desirable than the Proposed Action, particularly on busy days, and would continue to deteriorate as skiers and snowboarders seek more favorable, out-of-state opportunities. The ski area's reputation in Northern Arizona's recreational environment would continue to be defined by climatic conditions with a continued dependency on natural precipitation. While difficult to measure, skier export to neighboring states would be expected to continue, as warranted by snowfall and climatic trends.

As additionally detailed within the Social and Economic Resources section, operations under Alternative 3 would continue to be heavily dependant upon natural snowfall. Correspondingly, skier visitation levels, and therefore revenues, are not anticipated to stabilize. As such, it is probable that the owners of the Snowbowl would be unable or unwilling to continue to infuse the recurring capital necessary to maintain the quality and service level currently offered. Likely, a portion of the Alternative 3 improvements - those requiring smaller investments – would be developed. Dependant upon which facilities are ultimately implemented, the actual effects to the quality of winter recreation would realistically be a blending of those effects described under the No Action Alternative and those detailed under Alternative 3.

For the purposes of comparison, this section assesses the quality of winter and summer recreation opportunities assuming that *all* of the Alternative 3 improvements would be implemented.

Winter Recreation

Lifts and Terrain

Under Alternative 3, the aerial lift system and terrain development would be identical to that described under the Proposed Action.

Consistent Snowpack

The Snowbowl's reliance upon natural snowfall and variability in skier visitation would continue under Alternative 3. While it is probable that a series of infrastructural improvements may be made to the facility under Alternative 3, consistency of skiing conditions and predictability of operations would remain unchanged. It is probable that Arizonans would continue traveling beyond the state (into the Four Corners area) in search of better, more consistent snow conditions.

Terrain Density Analysis

Under Alternative 3, the terrain density anticipated under Alternative 3 would be essentially identical to that evaluated under the Proposed Action.[176]

Slope Aspect Analysis

The results of the slope aspect analysis conducted for existing terrain within the SUP area are provided in the Existing Conditions section. The majority of the proposed terrain additions are aligned in north/northwest aspects (which provide for optimal retention of snow); however, the terrain additions related to the development of the Humphreys Chairlift are not. A detailed slope aspect analysis was completed specific to the approximately 31 acres of skiing trails proposed within the Humphreys pod. The aspect of these trails averages 238.9 degrees azimuth, which would be characterized as southwest-west. The majority of the terrain (93.4 percent) lies southwest (180 to 270 degrees azimuth) with the remainder (6.6 percent) facing west to northwest (270 to 337 degrees azimuth).

The Humphreys pod does not offer an optimal slope aspect in terms of season-long snow retention. Although the ski trails have been specifically designed in a mosaic of open spaces with the intent of maximizing the shading potential of the existing tree canopy, it is anticipated that the aspect of these trails would cause them to melt-off periodically between storm cycles. Through a combination of natural shading and effective snow management, it is anticipated that under Alternative 3, the skiing terrain within the Humphreys area would provide an acceptable skiing product for roughly half of the Snowbowl's operating season.

Snowplay

Because construction and maintenance of the proposed snowplay facility would be dependent on a reliable source of snow (i.e., snowmaking), this facility would not be developed under Alternative 3. Thus, no additional recreational opportunities would be available to non-skiers within the SUP area during the winter. As described within the Existing Conditions section, a demonstrated demand exists for developed and dispersed snowplay activities. Under Alternative 3, the Snowbowl Road would remain closed to parking – and therefore snowplay activities would not be allowed along the Snowbowl Road. Despite efforts to inform the public of the parking and snowplay prohibitions, it is anticipated that numerous visitors would continue to drive up the Snowbowl Road only to be turned away by the parking staff.

Half Pipe

The half pipe, proposed to be constructed near the Sunset Lift, would add a currently unavailable element to Snowbowl's alternative terrain features. Similar to the Proposed Action, the proposed half pipe would be partially constructed of dirt, which would allow it to be operational without snowmaking coverage. However, the overall size and quality

[176] Negligible differences in terrain density are attributable to the Proposed Action's realignment of the Aspen Chairlift and utilization of some of the Hart Prairie terrain for the snowtubing areas.

of the half pipe would be reduced as compared to the Proposed Action due to the inability to augment its construction with machine-produced snow.

Upgraded Guest Services

Upgrading the ski area's uphill capacity (and therefore CCC) would necessitate making commensurate improvements to ski area-wide infrastructure[177] and guest service facilities. By increasing and updating Snowbowl's guest service facilities, the overall recreational experience would be improved (e.g., food service seating would be increased eliminating the need for guests to sit on the floor).

Summertime Recreation

Hiking

Under Alternative 3, the proposed hiking trail from Agassiz Lodge to the top of the Agassiz Chairlift would be developed as described under the Proposed Action.

Wilderness Values

Issue:

Implementation of the Proposed Action may affect the experience of wilderness users within the surrounding Kachina Peaks Wilderness.

Indicators:

Quantitative Description of Seasonal Wilderness Utilization and Visitation.

Narrative Discussion of the Anticipated Effects of the Proposed Action to Wilderness Users

The discussion within this section combines a description of the two identified indicators.

Alternative 1 – No Action

Selection of the No Action Alternative is not expected to directly or indirectly impact the Kachina Peaks Wilderness. Under this alternative summer and winter access, use and enjoyment of the Wilderness would not change. Annual utilization of the Wilderness would be expected to follow historic trends, as provided in Table 3F-6.

Alternative 2 and 3

Similar to the No Action Alternative, neither of the action alternatives would directly or indirectly impact summer or winter access, use or enjoyment of the adjacent Kachina Peaks Wilderness. All projects likely to occur under either of the action alternatives would be confined to the established Snowbowl SUP area, and no additional access to, or use of, the Wilderness is anticipated. Therefore, it is not anticipated that any of the changes occurring within the ski area would affect any Wilderness values or users. Annual utilization of the Wilderness would be expected to follow historic trends, as provided in Table 3F-6.

[177] Power, water, and sewer upgrades are detailed in the Infrastructure and Utilities section of this chapter.

CUMULATIVE EFFECTS

Scope of Analysis

Temporal Bounds

The temporal bounds of the cumulative effects analysis for recreation resources extends from the conception of Snowbowl as a developed winter recreational venue into the foreseeable future for which these opportunities can be expected to continue at the Snowbowl.

Spatial Bounds

The physical extent of this cumulative effects analysis comprises the Snowbowl SUP area and approximately 5,000 acres of the surrounding Kachina Peaks Wilderness (approximately one quarter of the total Wilderness acreage).

Past, Present, and Reasonably Foreseeable Future Actions

1. Wilderness designation
2. Miscellaneous facilities and trail construction within Snowbowl's SUP area
3. Summer events held at Snowbowl
4. San Francisco Mountain Mineral Withdrawal
5. Peaks segment of the Arizona Trail
6. Veit Springs Land Exchange
7. Private land development
8. Miscellaneous/ongoing recreational uses
9. Snowbowl Road Parking Restrictions Snowbowl Road Paving

Appendix C includes the full list of past, present and reasonably foreseeable future actions analyzed in this document, as well as background information on each of them.

Alternative 1 – No Action

The Snowbowl has existed on the San Francisco Peaks since 1938, and its developed character has necessarily grown over the decades in proportion to greater demand and utilization. The Kachina Peaks Wilderness was not designated by Congress until 1984 – well after the establishment of the majority of Snowbowl's existing facilities and trail systems. While it is acknowledged that the ski area and Wilderness represent different, and in some cases, conflicting, management emphases,[178] Snowbowl's operations and development have been, and continue to be, entirely confined to the SUP area and have been conducted in accordance with the terms of its SUP and Forest Plan standards and guidelines.

Many of the past, present or reasonably foreseeable future actions identified above are positive in nature when considered in a recreational context. For example, withdrawal of the Peaks and surrounding area from mineral entry (completed in 2000) has preserved the visual and recreational character and opportunities of the analysis area. The Peaks

[178] For example, portions of the lift and trail network can be seen from within the Wilderness. Noise is not considered an issue, as the Wilderness receives the majority of its use during the non-winter months when Snowbowl operations area minimal.

segment of the Arizona trail (a decision which is imminent at the time of this document's distribution) will provide additional hiking and interpretive opportunities in the cumulative effects analysis area. While not a large recreational benefit, the Ve it Springs land exchange will benefit recreation on the Peaks by consolidating lands in the analysis area and bringing them under consistent Forest Service management direction.

Recent parking restrictions on the Snowbowl Road have had the effect of shifting dispersed winter snowplay to other areas of the Forest as well as private land. This has improved access to the Snowbowl by reducing congestion on the Road. In addition, paving of the Snowbowl Road has improved use and access to the Snowbowl.

It is difficult to assess the effects of past, present and future private land development in Hart Prairie on recreational resources. Cumulatively, with development of the Snowbowl, this has brought more people, facilities, traffic and activity within close proximity to the Wilderness area and will continue with future development. This may lead to increased use of the Wilderness in the future. Miscellaneous/ongoing recreational uses of the area – both on and off-Forest, have increased over the years and will likely increase with or without selection of the No Action Alternative.

Summer events will continue to occur within the SUP area, as reviewed and approved on a case-by-case basis via Snowbowl's annual summer operating plan.

Alternative 2 – The Proposed Action

While the Proposed Action represents the greatest potential for effects to recreational opportunities in the cumulative effects analysis area, cumulative effects of implementation of the Proposed Action are anticipated to be largely the same as those described under Alternative 1, with the following exceptions:

Installation of snowmaking capabilities within the SUP area would provide an improved, more reliable snowpack within the SUP area, thereby, in all likelihood, deterring some dispersed winter use beyond the SUP area under less-than-favorable snow conditions.

By providing a developed snowplay facility within the SUP area, dispersed snowplay elsewhere on NFS and private lands would be reduced. This would alleviate safety, sanitation and vehicular/pedestrian congestion.

The establishment of the proposed hiking trail from the Agassiz Lodge to the top of the Agassiz Chairlift could offset some use of the Wilderness by reducing pressure on the Humphreys Peak Trail, and thus lessen impacts on Wilderness during the summer.

Alternative 3

Cumulative impacts associated with selection of Alternative 3 would be largely the same as those disclosed under Alternative 1.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

All projects elements have been designed to enhance the summer and winter recreational experience within Snowbowl's SUP area. No irreversible or irretrievable commitments of recreational resources were identified.

3G. INFRASTRUCTURE AND UTILITIES

INTRODUCTION

Neither public nor agency scoping identified potential effects to infrastructure and utilities as a significant issue for this proposal; however, changes would occur to both infrastructure and utilities under the two action alternatives. As a result, domestic water, wastewater, power, and fuel storage at Snowbowl are described and analyzed herein.

SCOPE OF THE ANALYSIS

The scope of analysis for the infrastructure and utilities section of this EIS focuses on the Snowbowl SUP area (NFS lands) and the length of the corridor from the City of Flagstaff to the ski area in which the reclaimed water would be piped from the Rio de Flag wastewater treatment facility to Snowbowl for use in the proposed snowmaking system and as a source of gray water for the ski area.

EXISTING CONDITIONS

WATER AND WASTEWATER

Because Snowbowl is located on a volcanic mountain in an arid landscape, a potable water source does not exist at the ski area. Therefore, all potable water is trucked to the ski area from the Bonito fill station in Flagstaff via a 3,200 gallon capacity tender truck. In a typical year, Snowbowl hauls approximately 1.5 million gallons of potable water. This equates to approximately 470 trips each year. During the ski season, Snowbowl hauls approximately 10,000 gallons of water per night on the weekends and 5,000-7,000 gallons of water per night mid- week. During the summer, the ski area utilizes approximately 10,000 gallons of water per week.

Potable water is held in aboveground storage tanks adjacent to each base area facility. The Agassiz Lodge, Hart Prairie Lodge, and maintenance facility have tanks of 10,000; 20,000; and 2,500 gallons, respectively. In addition to potable water for drinking, Snowbowl also has one 10,000 gallon water storage tank located across the road from the Hart Prairie Lodge for fire suppression as required by state and local laws.

Of the approximately 1.5 million gallons of water hauled to the ski area annually, approximately 60 percent (900,000 gallons) is consumed in restroom facilities. Each of the three main base area facilities at Snowbowl has an on-site, self-contained septic system and leachfield. The Agassiz Lodge, Hart Prairie Lodge, and maintenance shop have systems capable of treating 10,000; 10,000; and 1,200 gallons of wastewater per day, respectively. The septic systems are pumped annually, or as needed, to avoid overflow. Snowbowl's septic systems are adequately sized to meet current needs.

POWER

Electric power is provided to Snowbowl by Arizona Public Service (APS). A main line runs from Flagstaff to the ski area via an existing, overhead utility corridor, located south of the maintenance facility (refer to either figure 2-6 or 2-9). From here, an electric power line runs through the access road to the maintenance facility and to the Hart Prairie Lodge. Spurs from the Hart Prairie Lodge connect to the bottom of the Aspen Chairlift, the Hart Prairie Chairlift bottom and top terminals, the Agassiz Lodge, and the Agassiz Chairlift bottom terminal. The lifts at Snowbowl are individually powered by electric motors; the electrical requirements for each lift are detailed in the Table 3G-1. In the event of an electrical power outage, however, each lift has an auxiliary power unit (APU) powered by either gasoline or diesel fuel. This enables operation of the lifts in the event of a power outage. On average, APUs at each lift run fewer than 25 hours per year.

Table 3G-1
Electrical Requirements for Existing Lifts

Lift	Electrical Requirement (hp)
Agassiz	400
Hart Prairie	150
Sunset	150
Aspen	110

All facilities use electricity for lighting. Propane is the source of energy for heat and cooking. The main propane storage tanks are located in the base area, with one 1,000-gallon tank at the Agassiz Lodge, one at Hart Prairie (6,000 gallons), and one 1,000-gallon tank at the maintenance facility. Each lift shack has its own portable propane tank, which is transported to the bottle dock at the maintenance shop to be refilled as necessary. The large base area tanks are serviced and filled as needed.

FUEL STORAGE

Fuel is stored in an above ground tank at the maintenance facility, located approximately on-half of a mile south of the Hart Prairie Lodge. The tank holds 2,000 gallons of gasoline and 6,000 of diesel fuel. Additionally, each lift has a small fuel tank associated with its APU. These tanks contain enough fuel for approximately eight hours of operation.

COMMUNICATIONS

Communication services are provided to Snowbowl by Qwest. All communication lines at Snowbowl connect to the main line in the existing utility corridor (shared with power), south of the maintenance facility. From this connection with the main line, a phone line runs through the access road to the maintenance facility and to the Hart Prairie Lodge. Spurs from the Hart Prairie Lodge connect to the bottom of the Aspen Chairlift, the Hart Prairie Chairlift bottom and top terminals, the Agassiz Lodge, and the Agassiz Chairlift bottom terminal. While the existing network of communication lines throughout the SUP area are adequate to meet Snowbowl's existing operational needs, the system is currently maxed out and cannot be augmented without upgrading the main line. Refer to either Figure 2-6 or 2-9 for locations of exiting communication lines.

A two-way radio repeater is situated at 11,500 feet adjacent to the top patrol area. Mountain personnel, such as ski patrol, utilize line of sight radios for instantaneous communication while outdoors.

GUEST SERVICES

Existing on-mountain visitor services are provided in two buildings: the 18,425 square foot Hart Prairie Lodge (at the base of the Hart Prairie and Sunset chairlifts) and the 5,080 square foot Agassiz Lodge at the base of the Agassiz Chairlift. In total, these two buildings comprise approximately 23,505 square feet of guest service and administrative space.

There are presently a total of 614 indoor, cafeteria style seats and 648 outdoor seats available between the two buildings, for a total of 1,262 seats. Based on an average daily seating turnover rate of 4.0,[179] Snowbowl has indoor seating for approximately 2,450 guests. For Snowbowl's CCC of 1,880, this number of indoor seats is ample. However, because peak daily visitation has averaged 3,400 skiers in the past, it is apparent that current guest seating falls considerably short of what is actually needed to provide an adequate experience.

The kitchen/scramble[180] area in the Hart Prairie Lodge falls short of meeting Snowbowl's needs, or guests expectations, for quality services and facilities. On any day in which Snowbowl's attendance reaches 2,000 guests, the Hart Prairie Lodge experiences long food and cashier lines (sometimes extending out the door onto the deck), inadequate seating (resulting in guests sitting on the floor or standing while they eat) and general congestion throughout the building.[181] Restrooms are, however, considered adequate at the Hart Prairie Lodge.

Similar to the Hart Prairie Lodge, the Agassiz Lodge lacks adequate seating on even moderately busy days, which means that guests are forced to sit on the floor or stand while they eat or warm up. Due to outdated (1961) and undersized kitchen/scramble facilities, menu options are extremely limited and lines are unacceptably long. Restroom capacities are insufficient resulting in long waits.

[179] A turnover rate of three to five times is the standard range utilized in determining restaurant capacity. Sit-down dining at ski areas typcially results in a turnover rate of three, while cafeteria style dining is characterized by a higher turnover rate. Furthermore, weather has an influence on turnover rates at ski areas, as on snowy days skiers will spend more time indoors than on sunny days.

[180] The "scramble" area refers to the self-service and cashier line portions of cafeteria-style food service areas.

[181] This is especially true on days in which outdoor seating is undesireable due to weather conditions.

ENVIRONMENTAL CONSEQUENCES

DIRECT AND INDIRECT EFFECTS

Issue:

Effects on ski area infrastructure and supporting utilities within and beyond the SUP area.

Indicator:

Disclosure of Current Versus Anticipated Requirements for Guest Seating; Power, Domestic Water Supply and Wastewater Treatment.

Effects to infrastructure and utilities are primarily related to public safety, demand/consumption, efficiency, and reliability. Domestic water includes availability and quality of potable water for on-mountain consumption at restaurants and the proposed snowplay facility, as well as non-potable uses such as capacity, availability, and code compliance for fire suppression facilities (sprinkler systems) and restroom facilities. Sewer facilities include capacity, availability, and code compliance of restroom and restaurant wastewater facilities. Power (electrical distribution) facilities on the mountain are related to availability, reliability, and contingency planning. Fuel storage issues at Snowbowl are typically confined to public safety issues.

In addition to the narrative discussion of existing and proposed utilities provided here, refer to Table 2-5, Summary of Environmental Consequences, which quantifies both permanent and temporary ground disturbances associated with the installation of the described infrastructure under each alternative.

Alternative 1 – No Action

With selection Alternative 1, Snowbowl's CCC would remain at 1,880, and daily visitation (including peak visitation) would remain similar to that of the recent past – subject to weather conditions.

Water and Wastewater

Under Alternative 1, Snowbowl would continue to haul all of its domestic water from the City of Flagstaff. There would be no additional storage capacity and demand would be anticipated to remain the same.

Wastewater facilities currently meet the demands of the ski area, even on peak days. Snowbowl would continue to utilize approximately 60 percent of the water it hauls from Flagstaff to accommodate non-potable (i.e., toilet) services.

Power

Because the existing electrical service is adequate to meet Snowbowl's needs current needs, upgrades to power supply and distribution are not necessary under Alternative 1.

Fuel Storage

There is an adequate supply of gasoline, diesel, and propane storage at the ski area to meet existing demands.

Communications

Under the No Action Alternative service would continue to be provided by Qwest. No new or additional lines would be installed.

Guest Services

No changes would occur to guest service facilities under the No Action Alternative. Guest seating and restrooms would continue to be inadequate on even moderately busy days. Existing buildings would not be brought into compliance with the Americans with Disabilities Act (ADA) under the No Action Alternative.

Alternative 2 – the Proposed Action

The utilities and infrastructure discussed below are depicted on Figure 2-6.

In order to better accommodate existing demand, the Proposed Action would increase Snowbowl's CCC from 1,880 to 2,825. As stated, it is typical for ski areas to size infrastructure and guest services to accommodate as much as 125 percent of CCC. Under the Proposed Action guest service facilities and related infrastructure have been sized to accommodate approximately 3,000 guests. However, as was also stated, parking is, and will continue to be, a constraint to daily attendance, even with minor increases in parking areas.[182]

Water and Wastewater

Under Alternative 2, Snowbowl would continue to transport 100 percent of its potable water via truck from Flagstaff. While daily skier visitation is not anticipated to increase substantially, the occurrence of peak days is expected to increase in frequency and implementation of the proposed snowplay facility would increase demand for potable water at the Snowbowl. However, with construction of the reclaimed water pipeline from Flagstaff, it would no longer be necessary for the Snowbowl to use valuable potable water for non-potable services. Therefore, under the Proposed Action, 100 percent of trucked in potable water would be available for culinary uses; subsequently the frequency in which potable water is delivered to the ski area would decrease.

Snowbowl proposes to construct one additional 10,000-gallon potable water storage tank at the snowplay area to accommodate guests' needs there. In addition, water stored in the main snowmaking impoundment would be routed to the maintenance shop, the Agassiz Lodge, the Hart Prairie Lodge, and the snowplay facility for non-potable needs and for emergency fire suppression. Three additional 10,000-gallon (non-potable) water storage tanks would be constructed - one each at the Agassiz and Hart Prairie lodges, and one at the snowplay facility.

[182] Estimated at 2.5 guests per vehicle, Snowbowl's 10.6 acres of parking would continue to have a capacity of approximately 3,000 guests.

In order to accommodate the additional guest service facilities (specifically restrooms and food service operations), the on-site septic system for the Agassiz Lodge would be upgraded with an additional drainfield proposed to be located under the parking lot south of the Lodge (refer to Figure 2-6).

The septic system for the snowtubing area would be sized to accommodate peak day use of the facility. This would equate to approximately 1,680 snowtubers utilizing five gallons of water per day (capacity of 8,500 gpd). Ground disturbance for this system has been accounted for in the proposed grading for construction of the snowtubing area.

While the existing septic system at the Hart Prairie Lodge would not need to be enlarged, under the Proposed Action, the drainfield may be disturbed during conduction activities in the Hart Prairie area and therefore may warrant repair.

The reader is referred to figures 2-5 and 2-6 for locations of exiting/proposed leachfields in relation to proposed grading activities.

Snowmaking

Installation of a snowmaking system would require trenching for air, power, and water lines, as well as construction of a 10 million gallon on-mountain water impoundment. In the winter this storage pond would be used as a source of water for the proposed snowmaking system (and, to a lesser degree, for non-potable water needs at the ski area). In the summer, the water in the impoundment would be available for wildland firefighting operations as a high elevation water source. The storage pond would be easily accessible by helicopters, making it a valuable time conserving resource.

The Proposed Action includes installing fire hydrants along the pipeline corridor from Flagstaff. Strategically located, these hydrants, located on Observatory Mesa and in the Fort Valley residential community, would help protect these areas by providing expedited access to a readily available source of water for fire suppression in case of an emergency.

With very few exceptions, snowmaking is proposed on all existing and new trails under Alternative 2. A network of snowmaking water, power, and air lines would be buried on the south side of each trail to accommodate the proposed snowmaking under Alternative 2. Refer to Figure 2-3 for the proposed snowmaking air/water line configuration.

Power

Under the Proposed Action, the Hart Prairie, Sunset, and Aspen chairlifts would be upgraded and/or realigned; each would have a top drive terminal and would have various electrical power requirements as described in Table 3G-2. Each chairlift would also be outfitted with a diesel APU with fuel storage sufficient for one day of operation.

The new Humphreys Chairlift would have a bottom drive terminal requiring a 200 horsepower motor. Power to this lift would be supplied via a short spur off the proposed snowmaking water, power, and air line corridor that would run along the western edge of the proposed Humphreys pod. The proposed lift would also have a diesel APU with aboveground fuel storage for one operating day.

Table 3G-2
Electrical Requirements for Proposed Lifts

Lift	Electrical Requirement (hp)
Agassiz	435
Humphreys	200
Hart Prairie	250
Sunset	600
Aspen	75

With the addition of snowmaking infrastructure, new/upgraded lifts and other projects, Snowbowl's existing power supply is inadequate and would need to be upgraded. The increased demand for electricity associated with the upgraded Agassiz and Hart Prairie lodges, snowmaking system and upgraded lift network would be met by additional supply and infrastructure through APS. This could be achieved under two scenarios:[183] 1) by replacing and upgrading overhead power lines that currently enter the SUP area in its southwestern corner; or 2) by dismantling the exiting overhead power lines/infrastructure and installing a new, upgraded power line in the same trench as the reclaimed water line along the Snowbowl Road corridor. The proposed snowplay facility would be accommodated by a spur off of the upgraded infrastructure, under either scenario. The two existing lodges have an adequate supply of propane to meet the increased demand for heat in the upgraded facilities. The snowplay facility would require an additional propane tank for heating purposes.

Fuel Storage

Under the Proposed Action, an additional propane tank would be installed at the snowplay facility. No other changes/additions to fuels storage would be warranted.

Communications

Under the Proposed Action, the main telephone line servicing Snowbowl would need to be upgraded. Since this line currently shares the overhead corridor with power, the ultimate location of an upgraded line would depend on future discussion with APS and Qwest, because this line could easily be buried along with power and reclaimed water in the Snowbowl Road corridor. An additional line would be a buried from the maintenance facility to the proposed snowmaking primary pumphouse located adjacent to the water impoundment.

Guest Services

Proposed improvements to the Hart Prairie and Agassiz day lodges would help achieve a better balance between guest services and attendance levels. The Proposed Action would increase guest service square footage from approximately 23,500 square feet to

[183] Additional discussions with APS are pending final project engineering which is contengient upon project approaval.

approximately 47,000 square feet (including the enlarged Hart Prairie and Agassiz lodges, the snowplay facility, and the Native American Cultural and Education Center). Creating more guest service space (seating, restrooms, food service, kitchen/scramble etc.) would allow Snowbowl to better meet guests' needs on average and peak visitation days, when attendance could be expected to meet or exceed 3,400 guests. This would allow Snowbowl to respond to existing issues with inadequate guest service by providing facilities to accommodate 125 percent of the increased CCC. Under the Proposed Action, existing buildings would be brought into compliance with the ADA.

Alternative 3

The utilities and infrastructure discussed below are depicted on Figure 2-9.

As with the Proposed Action, Alternative 3 would size guest service facilities and related infrastructure to accommodate approximately 3,000 guests – approaching 125 percent of CCC. However, parking capacity would continue to be a constraint to daily attendance, even with minor increases in parking areas. As with the Proposed Action, in order to better accommodate existing demand, Alternative 3 would increase Snowbowl's CCC from 1,880 to 2,825.

Water

Without the snowmaking impoundment for non-potable water storage, Snowbowl would continue to utilize approximately 60 percent of the potable water it trucks to the ski area to accommodate its non-potable water needs. However, under Alternative 3 Snowbowl would construct an additional 10,000-gallon water storage tank at the Agassiz Lodge to help accommodate existing demands for potable water. As a result, the amount of water hauled and the cost associated with transportation would be slightly reduced, but would not significantly differ from the existing conditions.

As with the Proposed Action, in order to accommodate additional guest service facilities (specifically, increased toilets), the on-site septic systems for the three existing buildings may need to be upgraded in size under Alternative 3. Additional septic capacity for the Hart Prairie and Agassiz lodges would be the same as described under the Proposed Action. Final size and design (and need) for these systems would be directly related to the size of the proposed buildings, number of additional toilets and the number of people to be accommodated by each facility.

Power

Because Alternative 3 excludes snowmaking, Snowbowl's existing power supply is adequate to accommodate the anticipated demand under Alternative 3. However, several short spurs would be required to provide electric power to the new Humphreys Chairlift, the new surface lifts, and the proposed realigned Sunset and Hart Prairie chairlifts. Each of these lifts would have a top drive terminal and would have various electrical power requirements as described in Table 3G-2. One additional line would be buried within a mix of existing and proposed trails to the top of the Agassiz Chairlift.

As with the Proposed Action, the new Humphreys Chairlift would have a bottom drive terminal requiring an approximate 200 horsepower motor. Power to this lift would be supplied via a spur from the Agassiz Chairlift. The proposed lift would also have a diesel APU with aboveground fuel storage for one operating day.

Fuel Storage

There is an adequate supply of gasoline, diesel, and propane storage at the ski area to meet demands under Alternative 3.

Communications

Alternative 3 would not necessitate any changes to the existing communications network at Snowbowl.

Guest Services

Aside from the omission of the Native American Cultural and Education Center, Alternative 3 improvements to guest services would be identical to the Proposed Action.

CUMULATIVE EFFECTS

Scope of Analysis

Temporal Bounds

The temporal bounds of this cumulative effects analysis extend from when Snowbowl was established in 1938 through the foreseeable future in which Snowbowl can be expected to operate.

Spatial Bounds

The spatial bounds of this cumulative effects analysis are limited to the Snowbowl SUP area and the proposed pipeline corridor between the permit area and the Rio De Flag WWRF.

Past, Present, and Reasonably Foreseeable Future Projects

The only reasonably foreseeable future action that has been identified in relation to utilities and infrastructure is the Snowbowl wireless telephone communications site. No other specific past, present, or reasonably foreseeable future projects with potential to cumulatively affect infrastructure and utilities were identified as having occurred or likely to occur within the spatial and temporal bounds of this analysis.

Appendix C includes the full list of past, present and reasonably foreseeable future actions analyzed in this document, as well as background information on each of them.

Alternatives 1, 2 and 3

While approved for construction at Snowbowl's maintenance area, the wireless telephone communications site would not cumulatively affect infrastructure or utilities, other than potentially eliminating the need for land lines at Snowbowl in the future.

APS has indicated that sufficient power is available in the grid to meet Snowbowl's power needs under the Proposed Action. This could be achieved without affecting other APS customers.

The reader is referred to the cumulative effects analysis contained in Section H – Watershed Resources for information on cumulative impacts associated with private septic systems in Hart Prairie.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

There would be no irreversible or irretrievable commitments of resources as a result of either action alternative.

3H. WATERSHED RESOURCES

SCOPE OF THE ANALYSIS

The focus of this analysis is the potential impacts to watershed resources from implementation of the Proposed Action; specifically, proposed snowmaking operations which would utilize reclaimed water as the source for snowmaking.

The study area for this watershed analysis is depicted in Figure 3H-1. As opposed to the eight subwatersheds that compose the study area in the Soils and Geology analysis, the study area for the Watershed Analysis is comprised of two primary areas: the Hart Prairie Watershed and Agassiz Subwatershed. These areas were differentiated by the drainage divide along the ridge that runs west from Agassiz Peak. Within the Hart Prairie watershed the "Snowbowl Sub-area" further delineates the area of direct impact from the proposed snowmaking activities. The Snowbowl sub-area includes slightly over 1,000 acres of land encompassing the majority of the Snowbowl SUP area. The Snowbowl Sub-area consists of four subwatersheds, as defined in the Soils and Geology analysis - Snowbowl, Sunset, Hart Prairie, and Humphreys; each includes snowmaking coverage. The larger Hart Prairie Watershed (which would include inputs from the Snowbowl Sub-area) is used for indirect impacts to down-gradient shallow groundwater discharges/users.

A portion of the snowmaking is proposed to occur in terrain within the upper portion of the Agassiz Sub-watershed. The Agassiz Sub-watershed includes a small part of Snowbowl's southernmost terrain and proposed improvements that occur south from the drainage divide between the Snowbowl sub-area and the Agassiz sub-watershed. Four of the subwatersheds identified in the Soils and Geology analysis (Meadows and Lower, Middle, and Upper Agassiz Ridge) were lumped into the Agassiz Sub-watershed analyze the direct impact of snowmaking. Indirect impacts were evaluated for the potential groundwater underflow from the Agassiz Subwatershed to shallow groundwater discharging in downgradient springs on the southwest flank of Agassiz Peak.

Cumulative groundwater quantity and quality effects of the proposed snowmaking were considered in relation to: 1) bacterial contamination from past, present, and future land use activities in Hart Prairie, 2) potential long-term effects on the regional aquifer from diversions of reclaimed water for snowmaking, and 3) other past, present, and reasonably foreseeable future projects identified by the Forest Service ID Team.

A portion of the indicators that were decided upon for conducting this analysis (see Chapter 1) are most appropriately discussed in the Existing Conditions section, and are labeled as such.

Figure 3H-1: Study Area for Watershed Resource Analysis

STUDY METHODOLOGY

This analysis of potential impacts to watershed resources is excerpted from a technical report prepared in conjunction with this EIS entitled *Analysis of Watershed Resource Issues for the Arizona Snowbowl Facilities Improvement Environmental Impact Statement*.[184] The technical report, in its entirety, is part of the official project record and is available for review at the Peaks Ranger District office.

This analysis was conducted by reviewing pertinent records, permits, and required permit reporting provided by the City of Flagstaff and the Arizona Department of Environmental Quality (ADEQ) for the treatment and monitoring of the Rio de Flag water reclamation facility (WRF) influent and effluent. In addition, Federal and State requirements and standard industry practices, in Arizona and other states for the reuse and recharge of reclaimed wastewater, were reviewed.

Interviews were conducted with personnel responsible for the management, operation, and maintenance of the WRF and the reuse distribution system. Finally, water rights and the ability to reuse the effluent for the proposed snowmaking were evaluated by reviewing pertinent water case law and precedents set by Arizona municipalities.

Anticipated volumes of reclaimed water required for proposed snowmaking operations during dry, average, and wet climatic conditions were generated by Sno.Matic Controls and Engineering, Inc.[185] As detailed in the Soils and Geology section of this chapter, Resource Engineering, Inc.,[186] provided analyses for the following parameters for dry, average, and wet climatic conditions in the study area: precipitation; water loss to evaporation, transpiration, and sublimation; and the resulting water available for groundwater recharge or surface water runoff.[187]

Potential direct and indirect effects of proposed snowmaking were analyzed by the following means:

1. compiling and reviewing previous investigations that characterized the regional and local hydrogeologic and climatic conditions and watersheds in the San Francisco Mountain region

2. defining the sub-watersheds that comprise the study area, based on hydrogeologic conditions and modeling

3. compiling and analyzing data and reports for wells and springs in the study area

4. identifying downgradient users of groundwater or spring water

5. conducting a field reconnaissance of the study area

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[184] Errol L. Montgomery & Associates, Inc., October 2003
[185] Sno.Matic Controls and Engineering, Inc., 2003
[186] REI conducted the Soils and Geology analysis contained in Section I.
[187] Resource Engineering, Inc., 2003

6. evaluating the volumes of groundwater recharge available in the watersheds from natural precipitation and proposed snowmaking operations

7. calculating relative dilution of the applied effluent in groundwater recharge for varying climatic conditions

EXISTING CONDITIONS

HYDROGEOLOGIC SETTING

The Snowbowl is located on San Francisco Mountain in the Plateau Uplands Hydrogeologic Province of Arizona, a high desert plateau region where landforms are dominated by deeply incised canyons, high isolated mesas and buttes, and volcanic peaks.[188] The regional aquifers are relatively deep (generally more than 1,000 feet) and occur in sandstone and limestone units that are generally flat-lying. Groundwater movement in these aquifers occurs chiefly via fracture zones. The land surface over much of the San Francisco Mountain region consists of permeable volcanic deposits and fractured limestone, which provide for rapid infiltration of precipitation and results in meager surface water runoff.[189]

Although this region is often described as a "water-short area", groundwater is, in fact, truly abundant. However, depth to the most favorable aquifers is great, resulting in high costs for groundwater exploration and development programs. These high costs and lack of understanding of the groundwater systems, particularly for geologic conditions that control locations of prolific groundwater-yielding zones in the aquifers, has prevented more extensive development.[190]

Most of the annual precipitation in Arizona occurs in late summer and mid-winter. Although the late summer monsoons provide intense rainstorms, these storms are of relatively short duration and are believed to provide limited groundwater recharge due to high rates of evapotranspiration during the summer. It is the longer duration winter rains snowfall, and subsequent snowmelt, which provide most of the groundwater recharge to the aquifers in the Flagstaff region. On a long-term average basis, approximately 70 percent of the precipitation on San Francisco Mountain is winter snowfall from Pacific Ocean storm systems, and 30 percent is from annual monsoon storm systems originating in the southern Pacific Ocean and the Gulf of Mexico.[191] Groundwater level measurements reported for wells in the interior valley of San Francisco Mountain suggest that recharge occurs chiefly from winter precipitation.[192]

Losses of rainfall and snow to evapotranspiration and sublimation are high in the region. Work conducted by Northern Arizona University[193] has provided new insight to the magnitude of evapo-sublimation losses on the San Francisco Plateau. The results of this

[188] Cooley, 1963; Montgomery & Harshbarger, 1989
[189] Montgomery & Harshbarger, 1989
[190] Montgomery and others, 2000
[191] Jones, 1993
[192] Higgins, 1998
[193] Drs. Lee Dexter, Charles Avery, and Abraham Springer et al.

work are incorporated into the estimates for groundwater recharge used in this report. The climate for the Hart Prairie watershed and San Francisco Mountain region, together with citations of sublimation studies, is detailed in the Soils and Geology analysis of this chapter.

The Snowbowl is located in a prominent valley on the western slopes of San Francisco Mountain. The hydrogeologic features of the Snowbowl watershed and downgradient Hart Prairie watershed control, to a large extent, the movement and fate of snowmelt, stormwater runoff, groundwater recharge, and groundwater in the underlying perched aquifers and the regional aquifer system. Figure 3H-2 is a conceptual diagram showing hydrogeologic features in the Hart Prairie watershed.

Figure 3H-2: Conceptual Block Diagram for Hart Prairie Watershed

The volcanic cinders and debris, fractured lavas and breccias, pyroclastic rocks, and colluvial materials at land surface in the Hart Prairie watershed enhance rapid infiltration and downward percolation of snowmelt and surface water runoff. The permeability and storage capacity of the underlying sediments are sufficiently high to absorb available snowmelt.[194] Groundwater moves vertically downward into laterally discontinuous perched groundwater zones in the Sinagua formation and underlying volcanic rocks (refer to Figure 3H-2). Due to the complex interfingering and interlayering of the debris flows of the Sinagua Formation and the various types of volcanic deposits, the pattern of groundwater movement in the perched aquifers is complex.

The most important hydrogeologic units in the Hart Prairie watershed are the Sinagua formation and the adjacent and underlying volcanic rocks. Thickness of the Sinagua formation is about 200 to 250 feet, where penetrated by wells in Hart Prairie.[195] The Sinagua formation contains zones of silt and clay that retard, but do not stop, downward movement of groundwater and support transitory perched groundwater zones during rainy seasons and spring snowmelt. The perched zones occur at different depths in the Sinagua and are thin and laterally discontinuous. Springs and seeps occur where groundwater perched on these silt and clay zones intersects the land surface, and flow rate is strongly dependent on seasonal precipitation.[196] After snowmelt, perched groundwater in the base of the Sinagua slowly percolates to deeper perched zones in the volcanics or to the regional aquifer, and the perched water table declines steadily until the Sinagua is drained or until another recharge event occurs.[197]

Due to the complex movement of groundwater through the Sinagua formation and underlying volcanic deposits in this area, it is not presently possible to precisely project where snowmelt infiltrated from upslope areas flows in the downgradient Hart Prairie watershed. The analyses of hydrogeologic units and groundwater levels suggest that much of the upslope snowmelt infiltrates downward below the surficial level of the springs and seeps that are found more than 3,500 feet downgradient from the Hart Prairie base area (refer to Figure 3H-1). In addition, available data regarding the rates and variability of discharge to springs from shallow groundwater zones in the Hart Prairie area indicate that recharge within relatively small catchments proximal to the springs could be the primary sources for the springs.

An inventory of records available for wells and springs in the Hart Prairie watershed area is contained in the technical report from which this analysis is excerpted. Locations for these wells and springs are shown on figures 3H-1 and 3H-3. The location of private and state land is depicted on Figure 3H-3. Records are available for 43 wells and eight springs in the approximate 25-square-mile area. Seventeen of these wells are not shown because they are shallow monitoring or exploration wells installed to depths of four feet or less for purposes of research associated with The Nature Conservancy Headquarters. Of the 26 wells shown, nine wells are reported to be used for domestic purposes, one well is used for both domestic and livestock purposes, 11 wells are unused or abandoned, and three wells piezometer/monitor wells. The type of use is not reported for two of the wells

[194] Halpenny, 1971; W.S. Gookin & Associates, 1974
[195] Halpenny, 1972
[196] Harshbarger, 1972
[197] Halpenny, 1971

shown. Detailed drilling data, such as depth drilled and a log of the sediments penetrated, is not available for many of the wells.

Eight spring areas are depicted on Figure 3H-3. Otto, Wilson, and Colton springs are located in the Hart Prairie watershed (Figures 3H-1 and 3H-3). Wilson and Colton springs are used for domestic water supply. The unnamed spring on state land, Big Leroux, Little Leroux, and Taylor spring are located in the larger Rio de Flag watershed and are all owned by the Forest Service. Big and Little Leroux springs are reported to be used for domestic and fire control purposes. The unnamed spring and Taylor Spring are reported to be unused.

Figure 3H-3: Well and Spring Location Map

Chemical quality of groundwater in the study area has been characterized by analysis of water samples obtained from: Wilson Springs; the unnamed spring on state land; the Camp Colton water system; wells SP-1, SP-4, SP-7, and SP-8, which were drilled in the north half of Hart Prairie to depths ranging from 349 to 1,175 feet; and two shallow wells that were drilled to depths of nine and 13 feet north from The Nature Conservancy Headquarters. Results of available laboratory chemical analyses for inorganic chemical constituents indicate that water quality is somewhat variable across the different sources, but is generally "very good" and meets all Federal primary and secondary drinking water standards. Concentrations of dissolved solids are generally somewhat larger for the deeper wells than for the springs and shallower wells, suggesting more significant geochemical interaction associated with deeper percolation and longer residence time of recharge water reaching the deeper wells. Water quality concerns are limited to potential impacts to perched aquifers from leaching of untreated wastewater from septic systems in the Hart Prairie area. Based on laboratory chemical analyses, water type for the shallow perched groundwater system in Hart Prairie is predominantly calcium bicarbonate.

Regional Hydrogeologic Units

Detailed descriptions of the individual rock formations and aquifers in the San Francisco and Coconino plateaus region are provided elsewhere,[198] and are therefore not repeated in this analysis, which focuses on local conditions in the Hart Prairie watershed. In the Flagstaff region, the most important geologic strata that control groundwater movement and storage, in descending order, are: unconsolidated sediments (alluvium, colluvium, and volcanic debris); volcanic rocks; Moenkopi Formation; Kaibab Formation; Toroweap Formation; Coconino Sandstone; Hermit Shale; Schnebly Hill Formation; Supai Group; Redwall Limestone and Muav Limestone; Bright Angel Shale; and Tapeats Sandstone.[199]

The most important aquifer systems for the Coconino and San Francisco plateaus are the C-aquifer system and the R-aquifer system. Both are described as regional aquifer systems; however, the R-aquifer system is by far the most important for groundwater transmission and storage, and is truly regional. Perched aquifers also occur at places above the C- and R-aquifers and contain and transmit small amounts of groundwater. These perched aquifers are thin and discontinuous[200] and commonly depend on annual recharge to sustain yield to wells and springs.

The C-aquifer includes the Coconino Sandstone and adjacent water-bearing strata including places in the sub-basins, Toroweap Formation, Kaibab Formation, Schnebly Hill Formation, and the upper part of the Supai Group. The R-aquifer includes the carbonate rocks of the Redwall Limestone and adjacent water-bearing strata, such as Muav Limestone and Martin or Temple Butte Formation, and in some cases the brittle rocks in the lower part of the Supai Group.

[198] Harshbarger & Associates and John Carollo Engineers, 1972-1974; Harshbarger & Associates, 1976; Montgomery & DeWitt, 1974-75 and 1982; Errol L. Montgomery & Associates, Inc., 1985, 1992-93, 1996, and 1998; Montgomery et. al., 2000; and Bills et. al., 2000

[199] Montgomery and others, 2000

[200] Montgomery and others, 2000

Regional Groundwater Circulation and Storage

Groundwater beneath the Coconino and San Francisco plateaus originates as recharge from infiltration of rainfall and snowmelt. Long-term average annual recharge must be equal to the amount of groundwater discharge of more than 260,000 acre-feet per year (AF/yr).[201] This rate of recharge is in the magnitude of four percent of total average annual precipitation on the plateaus. Groundwater storage may be in the magnitude of five million AF, and is estimated as the product of approximately 10,000 square miles, average saturated thickness of 800 feet, and average specific yield or drainable porosity of 0.1 percent.[202]

In the Flagstaff area, downward-moving recharge water ultimately passes all upper perching horizons and reaches the C-aquifer, where large amounts of groundwater storage occur over limited areas. In the Flagstaff Woody Mountain and Lake Mary wellfield areas, located along the Oak Creek and Anderson Mesa Faults, respectively, all rock units from the C-aquifer downward are saturated.[203] Groundwater in the saturated zone of the C-aquifer moves laterally and downward, very slowly in areas of non-fractured rock, and less slowly in areas where abundant fractures occur. At distances of a few miles to a few tens of miles from the Lake Mary and Woody Mountain wellfield areas, saturated thickness in the C-aquifer diminishes to zero or near zero due to full drainage of the groundwater downward to the R-aquifer system. After groundwater passes downward to the R-aquifer, it provides groundwater storage in the regional system, and moves slowly toward the Colorado and Verde river drains, chiefly along arterial fractured rock aquifer zones related to regional geological structures.[204]

Discharge from the Regional Aquifers

The amount of groundwater that moves through the C- and R-aquifers can be estimated by summing the flow from large springs that occur on the margins of the plateaus, where groundwater discharges to tributaries of the Colorado and Verde rivers. A long-term average annual volume of more than 260,000 AF of groundwater discharges from the margins of the Coconino and San Francisco plateaus each year.[205] Of this amount, about two-thirds discharges to the Colorado River from the R-aquifer system at Blue Springs and Havasu Springs. About one-third of the natural groundwater discharge is to the Verde River, and occurs from both the C- and R-aquifers.[206] Other smaller springs, including Garden and Hermit Springs, and small perched aquifer springs and seeps, discharge groundwater to the Colorado River from the plateaus, but are not important for present purposes of summing total amount of groundwater discharge from the plateaus. Although the amount of groundwater that issues from these springs is small, the springs have environmental importance. Additional groundwater discharges from the plateaus to the Colorado River at locations where rocks of the R-aquifer crop out at river level. These outcrop areas are chiefly near the confluence of Havasu Creek with the Colorado River, but also occur in the lower reaches of Marble Canyon above the confluence of the

[201] Montgomery and others, 2000
[202] Id.
[203] Id.
[204] Id.
[205] Id.
[206] Id.

Little Colorado River with the main stem of the Colorado River. These amounts of groundwater discharge are unknown.[207]

Total groundwater discharge to the Verde River from the Coconino and San Francisco plateaus is estimated at 95,000 AF/yr.[208] Of this amount, roughly 10,000 AF/yr issues from the C-aquifer and about 85,000 AF/yr issues from the R-aquifer. Groundwater discharge from the R-aquifer system to the upper reaches of the Verde River, in the vicinity of Summer's Spring, located in the Sycamore Canyon drainage, is about 45,000 AF/yr. This groundwater is derived from the southern part of the Coconino Plateau.[209] About 10,000 AF/yr of groundwater discharge from the C-aquifer occurs from Sterling Spring, in the upper reaches of Oak Creek, and from gains in base flow of the creek to roughly the location of Indian Garden. About 40,000 AF/yr issues from the R-aquifer system to the lower part of Oak Creek below Sedona; much of this discharge occurs at Page Spring. This groundwater originates on the southern part of the San Francisco Plateau.[210] Groundwater movement in the Oak Creek Canyon area is strongly influenced by fractured rock zones along the Oak Creek fault system and related faults in the Sedona area.

City of Flagstaff Groundwater Use

The Flagstaff municipal water supply system obtains groundwater from three principal wellfields and surface water from Upper Lake Mary – a man-made reservoir.[211] In drier periods when surface water is less abundant, Flagstaff relies heavily on groundwater from municipal wellfields. In 2002, only roughly 196 AF, or about two percent, of water used was obtained from Upper Lake Mary, and roughly 8,573 AF, or 98 percent, was groundwater pumped from municipal wellfields.[212] Over the last decade (1993-2002), about 75 percent of the water used by Flagstaff has been groundwater. During years of drought, such as 1989, 1990, and 2002, Upper Lake Mary may be nearly dry, and a much larger fraction of water used is obtained from groundwater.

The earliest Flagstaff municipal water supply was from springs located in the Inner Basin of the San Francisco Peaks. The pipeline from the springs to Flagstaff was completed in 1899.[213] Beginning in 1966, the Inner Basin groundwater supply was further developed by construction of production water wells. Groundwater supply from the Inner Basin is vulnerable to drought; when drought conditions threaten the water supply from Upper Lake Mary, water yield from Inner Basin springs and wells is also diminished.[214] Groundwater in the Inner Basin is stored in a perched aquifer system that lies far above the regional C-aquifer, which is used for Flagstaff's other municipal wellfields. In 2002, about 25 AF of groundwater was obtained from the Inner Basin by the City.[215]

[207] Id.
[208] Id.
[209] Id.
[210] Id.
[211] Montgomery and DeWitt, 1982
[212] City of Flagstaff, 2003
[213] Montgomery and others, 2000
[214] Montgomery and DeWitt, 1982
[215] City of Flagstaff, 2003

In 1956, Flagstaff began development of a wellfield in the regional C-aquifer near Woody Mountain, which now consists of 10 production water wells. In 2002, a total of about 4,780 AF of groundwater were yielded to the Flagstaff municipal system from these wells.[216] After the Woody Mountain wellfield was established, deep wells were also constructed in the C-aquifer in the Lower Lake Mary area, and these successful wells established the Flagstaff Lake Mary wellfield. In 2002, a total of about 3,335 AF of groundwater were yielded from seven wells in the Lake Mary wellfield.[217]

Recently, additional groundwater supply has been obtained from deep wells in the C-aquifer constructed along the Rio de Flag drainage on the east side of the city. These wells include the Continental-2 well, Fox Glen-1 well, Shop well, and Interchange well. In 2002, a total of about 433 AF of groundwater were yielded from these wells.[218]

Other Groundwater Use

Other wells are completed in the C-aquifer in the Flagstaff area and chiefly supply local water companies and individual developments. Total amount of groundwater use from these other wells is unknown, but is estimated to be small compared to City of Flagstaff use.[219]

Although most of the water used on the Coconino and San Francisco plateaus occurs at Flagstaff, substantial amounts have been developed, and are used by Sedona, Williams, Tusayan, and Grand Canyon Village. One of the principals of groundwater hydrology is that, over the short-term, groundwater pumped from wells is obtained solely from groundwater storage in aquifers. Over the long-term, the source of groundwater begins to be accounted for as reduction of natural discharge. For the Coconino and San Francisco plateaus, reduction of natural discharge must be accounted for chiefly by reduction in groundwater discharge to springs along the Colorado and Verde river drains. Total groundwater used on the plateaus, including Sedona, was about 8,000 AF/yr in 2000.[220] This total use represents about three percent or less of discharge to springs along the Colorado and Verde rivers, and about 0.2 percent of estimated groundwater in storage.

An important, but small, supply of groundwater proximate to the study area is obtained from wells completed in thin, discontinuous perched groundwater zones in the alluvium, colluvium, and volcanic rocks above the Moenkopi Formation in Fort Valley. Records for more than 240 wells are reported for Fort Valley,[221] which is located along the Rio de Flag drainage, about three miles south of the study area. These perched groundwater zones occur in permeable sediments on top of silt and clay lenses in the alluvial and colluvial deposits, in permeable cinders and fractured volcanic deposits on top of interflow clay layers or non-fractured lavas in the volcanic rock sequence, and in

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[216] City of Flagstaff, 2003
[217] Id.
[218] Id.
[219] Bills et. at., 2000
[220] Montgomery and others, 2000
[221] Allen, 1995

fractures in the upper part of the Moenkopi Formation. Depth to water in wells has been reported to range from two to 250 feet.[222]

WASTEWATER TREATMENT AND REUSE

Prior to treatment, municipal wastewater contains many chemicals and microorganisms that, if released to the environment untreated, could cause adverse ecological effects, or may present known or potential health risks to humans, if ingested.[223] Concentrations of constituents potentially harmful to public health or the environment are required to be reduced or eliminated prior to reuse. The amount of required reduction or removal depends on the planned reuse.

The U.S. Environmental Protection Agency (EPA) regulates most aspects of wastewater treatment and treatment plant discharges under the Clean Water Act (CWA). The CWA requires all discharges to waters of the United States to obtain a National Pollutant Discharge Elimination System (NPDES) Permit. Although the intent of the CWA and NPDES Permit program is to regulate discharges to surface water, the program provides a broad framework of command and control for municipal wastewater treatment so as to reduce or eliminate concentrations of constituents potentially harmful to public health or the environment. In particular, the NPDES Permit requires pretreatment to control the discharge of industrial pollutants to sewers and mandates that the discharge comply with specified technology-based effluent limitations and monitoring and reporting requirements. The CWA also compels federal and state governments to promulgate specific water quality standards to protect the physical, chemical, and biological integrity of the state's surface water for designated use categories that include: drinking water source (DWS); fish consumption (FC); full-body contact (FBC); partial-body contact (PBC); and aquatic and wildlife (A&W).

In practice, States have typically adopted wastewater discharge regulations similar to the Federal NPDES program. Although the EPA delegates authority to the States for the regulation of NPDES discharge permits, few States have developed enforceable programs and criteria to specifically regulate water reuse. Among the States that have developed programs, California, Florida, and Arizona are at the forefront.[224] Arizona wastewater reuse regulations are discussed in subsequent sections of this chapter.

Wastewater Treatment

Municipal wastewater treatment is a multi-stage process intended to remove or reduce organic matter, solids, nutrients, and disease-causing organisms that are present in raw wastewater generated from community residences, businesses, and industries. Typical untreated municipal wastewater is comprised of 99.94 percent water and 0.06 percent dissolved and suspended material.[225]

Conventional wastewater treatment begins with preliminary screening to remove debris and large solid material present in the waste stream that could damage or clog pumps,

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[222] Allen, 1995

[223] National Research Council, 1982

[224] National Research Council, 2003

[225] Water Pollution Control Federation, 1989

valves, piping, and other equipment. Mechanical bar screens, comminutors (grinding equipment analogous to large-scale kitchen sink garbage disposals), and grit chambers are used to separate solid debris from wastewater. The collected debris is commonly disposed on in a landfill. The screened wastewater is then put through primary treatment.

Primary treatment separates suspended solids in a clarification tank or sedimentation basin. Primary treatment removes slightly more than one-half of the suspended solids and one-third of the biochemical oxygen demand (BOD)[226] from decomposable organic matter. It also removes some nutrients, pathogens, trace elements, and potentially toxic compounds.[227] Solids are drawn off the bottom and skimmed off the top of the tank or basin, where they receive further treatment as sludge. The clarified wastewater flows to the next stage of treatment.

Secondary treatment is a biological process designed to remove dissolved organic matter from wastewater. Typically, microorganisms are cultivated and added in suspension (in the "activated sludge" process) or attached to media (in the "trickling filter" process) to remove biodegradable organic material. Secondary treatment processes can remove up to 95 percent of the remaining BOD and suspended solids, as well as significant amounts of heavy metals and dissolved organic compounds.[228]

Final treatment focuses on removal of disease-causing organisms in wastewater. Treated wastewater can be disinfected by adding oxidants, such as chlorine, by ultraviolet light radiation, or by ozonation.

Further treatment of wastewater by various advanced treatment processes is necessary in some systems to meet more stringent discharge or reuse requirements or to address particular water quality concerns associated with the source water. Advanced treatment may include biological methods, ion exchange, chemical precipitation, filtration, reverse osmosis, air stripping, carbon adsorption, electrodialysis, and other variations of these treatment processes for additional removal of suspended solids, nutrients, dissolved inorganic compounds, dissolved organic compounds, and microorganisms.[229] An overview of the Rio de Flag Water Reclamation Facility treatment process is given in a subsequent section of this chapter.

Wastewater Constituents

Chemical Constituents

Wastewater contains a combination of chemical constituents from a wide variety of natural or anthropogenic sources. The types and amounts of these constituents vary depending on: the source of the municipal water; the types of industrial, commercial, and household wastes discharged to the treatment plant; and the effectiveness of industrial pretreatment and source control programs. Municipal water use generally leads to an

[226] A measure of the pollution present in water, obtained by measuring the amount of oxygen absorbed from the water by the microorganisms present within it.

[227] National Research Council, 2003

[228] Water Pollution Control Federation, 1989

[229] Asano, 1998

increase in mineral and organic content relative to the original water quality.[230] The increase in concentration of dissolved solids and organics by municipal use has an important influence on the degree to which the water can be reclaimed for reuse.

Although many studies have investigated the toxicology of specific chemical constituents that may be present in wastewater, limited data is available to assess potential public health effects from concentrations and combinations of chemical constituents that occur in wastewater. Several detailed studies have examined potential human health hazards associated with drinking reclaimed water at Windhoek, South Africa, the only city in the world that has implemented direct potable reuse, and in Denver, Colorado, where direct reuse was rigorously assessed, but not adopted. Those studies suggested that no adverse health effects should be anticipated from the direct reuse of reclaimed water for drinking water purposes at these sites.[231] Two major studies have evaluated the health effects associated with ingestion of groundwater that has commingled with effluent in the subsurface as a result of wastewater recharge operations in California's Orange and Los Angeles counties. In these counties, recharge of secondary wastewater effluent had occurred for more than 30 years, resulting in populations being exposed to as much as 38 percent effluent in their drinking water supplies.[232] Results of the comprehensive epidemiologic evaluation concluded there were no adverse health effects in populations exposed to the effluent compared to unexposed populations in the area.[233]

Inorganic Constituents

Inorganic chemical elements and compounds generally occur in wastewater as a result of naturally-occurring minerals and inorganic salts present in the parent water supplies. Inorganic constituents are also contributed to wastewater from industrial, commercial, and other human activities, and from chemicals added during water and wastewater treatment and distribution.

Naturally-occurring minerals, such as sodium, calcium, sulfate, and chloride, are commonly found in municipal water supplies at concentrations ranging from one to several hundred milligrams per liter (mg/L). The concentrations of these constituents, and of nitrogen-containing compounds and other inorganic salts, increase as water is used and then collected as wastewater.[234] Except for nitrogen contributed from human bodily wastes, water quality concerns for these common inorganic ions and salts are generally limited to effects on taste, odor, and aesthetics. The presence of naturally-occurring trace metals and ions, such as arsenic, chromium, copper, boron, and fluoride, could pose potential human health and environmental hazards.

Industrial, commercial, and household discharges can contribute inorganic constituents, such as antimony, cyanide, mercury, chromium, cadmium, lead, zinc, selenium, silver, and sulfides, to wastewater which may inhibit the effectiveness of wastewater treatment or may pass through the process without treatment or removal. Proper characterization of

[230] Snoeyink and Jenkins, 1980

[231] National Resource Council, 2003

[232] Karimi and others, 1998

[233] Nellor and others, 1984; Sloss and others, 1996 and 1999

[234] National Research Council, 2003

wastewater discharges to a treatment plant and appropriate pretreatment and source control at the significant points of industrial discharge can assure the physical, chemical, and biological integrity of the wastewater treatment process and receiving waters.[235]

Human bodily wastes contribute high levels of nitrogen, phosphorous, and ammonia to wastewater that may cause adverse ecological effects to receiving waters if untreated. Phosphorous can be removed efficiently from wastewater by chemical precipitation or various biological processes. Ammonia and nitrogen can be removed by biological nitrification and denitrification.[236]

Organic Constituents

Organic constituents of concern principally include a number of conventional solvents, pesticides, polycyclic aromatic hydrocarbons, polychlorinated biphenyls (PCBs), and dioxin. Toxic substances used in homes, including motor oil, paint, household cleaners, and pesticides, may be found in municipal wastewater. Control of organic constituents in surface waters is necessary to limit impacts to health of downstream users and preserve sensitive aquatic environments. Recent studies of many rivers and waterways downstream from industrial and municipal discharges have identified elevated levels of toxic pollutants in water, sediments, and fish tissues.[237] Some of the organic constituents are persistent in the environment and can accumulate in animal tissues. Compounds, such as PCBs and pesticides, that bioaccumulate can pose a greater hazard to animals high in the food chain and may pose human health risks.

Through substantial research, extensive monitoring, and applied studies, EPA identified a number of organic chemicals as “toxic pollutants” during early implementation of the Clean Water Act.[238] 126 of the toxic pollutants, chiefly organic chemicals with a smaller number of metals and other substances, were assigned a high priority for development of water quality criteria and effluent limitation guidelines. The 126 “Priority Pollutants” were generally selected because they are frequently found in wastewater. EPA adopted federal water quality criteria for the Priority Pollutants to identify maximum chemical concentrations deemed protective of aquatic life and human health. These Priority Pollutants have become the basis for evaluating the chemical character of effluent from municipal wastewater treatment plants.

Disinfection By-products

Disinfection by-products (DBPs) are a class of chemical compounds produced during the process of wastewater disinfection. Disinfectants, in addition to killing microorganisms, react with organic and inorganic substances present in the water to produce a variety of DBPs. During chlorine disinfection, chloroform and other trihalomethanes (THMs) and haloacetic acids are commonly formed. Disinfection with ozone may result in the formation of bromate. Nitrosodimethylamine is a by-product of disinfection with chloroamines.

[235] Asano, 1998

[236] National Research Center, 2003

[237] U.S. Environmental Protection Agency, 2003a

[238] 42 U.S.C. 13101, et seq.

A small number of DBPs are regulated or are being considered for regulation due to potential human health concerns. The EPA established a primary drinking water standard of 100 mg/L for total THMs in 1979, based on the risk of cancer reported in animal studies evaluating chloroform toxicity. Chloroform is the most common THM found in drinking water.[239] By 1998, new epidemiological studies had been published that reported associations between THMs and bladder and colon cancer, as well as adverse pregnancy outcomes.[240] In response to these findings, the drinking water standard for total THMs was revised in December 1998 to 80 mg/L. Limits of 60 mg/L for haloacetic acid and 10 mg/L for bromate were also introduced.

Literature Search and Narrative Description of the Potential Presence of Pharmaceuticals, Pathogens, and Hormones in Class A Reclaimed Water (Indicator)

During the last three decades, the concern about wastewater quality has focused predominantly on conventional industrial pollutants. More recently, it has been recognized that a wide range of other synthetic organic chemicals originating from pharmaceutical drugs and personal care products may persist in the environment. These chemicals are continually released into the environment in large quantities through the manufacture, use (via excretion), and disposal of personal care products and drugs.[241] Research has shown that these chemicals enter and disperse into the environment from municipal wastewater treatment effluent, and persist to a greater extent than originally anticipated.[242] Studies[243] indicate that between 50 and 90 percent of a typical drug dosage can be excreted and introduced unchanged into the environment.

Concerns regarding pharmaceuticals and personal care products (PPCPs) have captured recent attention from governments in Europe and North America, the scientific community, the chemical industry, and public interest groups. The core issue centers on the potential harmful impact PPCPs may have on the normal function of the endocrine system[244] in wildlife and humans.[245] Endocrine-disrupting compounds can mimic, stimulate, or inhibit the production of natural hormones, thereby disrupting the endocrine system function.[246] Endocrine-disrupting compounds encompass a variety of chemical classes, including natural and synthetic hormones, pesticides, compounds used in the plastics industry and consumer products, and other industrial by-products and pollutants.[247] It is important to note that PPCPs and endocrine disrupting compounds are not synonymous. Only a small subset of PPCPs are known or suspected of being direct-acting endocrine disrupting compounds.[248]

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[239] U.S. Environmental Protection Agency, 1992

[240] Resource Engineering, Inc. and others, 2000

[241] Daughton and Ternes, 1999

[242] Kolpin and others, 2002; Cordy and others, 2003

[243] McGovern and McDonald 2003

[244] The endocrine system is a set of glands and hormones that control biological reproduction, growth, and development.

[245] World Health Organization, 2002

[246] McGovern and McDonald, 2003

[247] World Health Organization, 2002

[248] Daughton and Ternes, 1999

Much of the concern over endocrine-disrupting compounds stems from the impact that environmentally persistent pesticides and manmade organic compounds have had on exposed wildlife populations and the environment. Colborn and others[249] have linked endocrine-disrupting compounds in the environment to aberrant sexual development and behavioral and reproductive problems in animal populations. Colborn further suggested that endocrine disruptors could be responsible for a wide range of human health problems, including declining male sperm counts, growing incidence of infertility and genital deformities, increasing rates of breast and prostrate cancers, and neurological disorders in children. However, the linkage between animal studies and human health effects is controversial. Some scientists question whether the stated human health effects, such as declining sperm counts, are even occurring,[250] and dispute causal linkage of relatively low levels of exposure to synthetic endocrine disruptors.[251]

Municipal wastewater contains a variety of PPCPs that are pharmaceutically active and known to act on the endocrine system at therapeutic doses.[252] Although the occurrence of antibiotics and steroids has generated nearly all the controversy to date, many other classes of drugs, bioactive metabolites and transformation products, and personal care products have yet to be examined.[253] Chemicals found in both non-prescription and prescription medications have been detected in municipal wastewaters and may act as endocrine disruptors.[254] In addition to prescribed human drugs, other PPCPs of potential concern include veterinary and illicit drugs and such common substances as caffeine, cosmetics, food supplements, sunscreen agents, solvents, insecticides, plasticizers, and detergent compounds.

The occurrence of trace concentrations of a variety of PPCPs in surface water and groundwater is becoming progressively more widely recognized. The USGS[255] conducted a national reconnaissance of 139 streams in 30 States and detected PPCPs in 80 percent of the streams sampled. Another study[256] found more than 50 PPCPs in samples of wastewater treatment effluent, surface water, and groundwater. Until recently, the significance has largely gone unnoticed because there have been few analytical methods capable of detecting these compounds at the small concentrations expected in the environment, which are generally less than a microgram per liter (part per billion).

PPCPs and their effects as endocrine disruptors are generally viewed as more of a hazard to the aquatic environment because the introduction of PPCPs into the environment occurs chiefly through aquatic systems.[257] Aquatic organisms are the receptors most affected by uptake of potential endocrine disruptor compounds in the environment and, therefore, are the principal focus of PPCP-related environmental studies.[258]

[249] Our Stolen Future, 1997
[250] National Research Council, 1999
[251] Christensen, 1998; Safe, 2000
[252] McGovern and McDonald, 2003
[253] Daughton, 2001a and 2001b
[254] Daughton and Ternes, 1999
[255] Kolpin and others, 2002
[256] Daughton and Ternes, 1999
[257] Id.
[258] Sattelberger, 2002

The fundamental issue related to PPCPs in municipal wastewater is whether or not PPCPs and their transformation products can cause physiological effects on biota at the low concentrations detected.[259] Recent research indicates that endocrine disruptors may have aquatic habitat impacts, but no human health impacts, at concentrations found in receiving waters. [260]

A current and definitive analysis of the issue is given in the *Global Assessment on the State-of-the Science of Endocrine Disruptors*, prepared by an expert panel on behalf of the World Health Organization, the International Labour Organization, and the United Nations Environmental Programme.[261] The scientific evidence, as summarized in this report, indicates that certain effects observed in wildlife can be attributed to chemicals that function as endocrine disruptors. However, in most cases, the evidence of a causal link is weak, with the majority of the effects being observed in areas where exposure to chemical contamination was high at sites of spills and industrial wastewater discharges. The expert panel concluded that most PPCPs considered endocrine disruptors present "suspect", rather than "known", risks because our current understanding of the effects posed by endocrine disruptors to wildlife and humans is incomplete. With respect to human health, the expert panel stated that the only evidence that humans are susceptible to endocrine disruptor compounds is provided by studies of high exposure levels. Generally, the panel noted that studies investigating endocrine disruption effects in humans have yielded inconsistent and inconclusive results and that more rigorous studies are recommended.

Currently, the City of Flagstaff is conducting applied research to screen for the presence of potential endocrine-disrupting compounds and other PPCPs in treated wastewater and to characterize the endocrine-disrupting potential on target vertebrate organisms.[262] The research is being conducted in two phases. In the first phase, the USGS, in an extension of their national reconnaissance of organic wastewater contaminants, will sample and quantitatively analyze treated wastewater samples from City of Flagstaff wastewater for 94 chemicals. The analytes include those PPCPs previously identified in the highest detection frequency and suspected as endocrine-disrupting compounds in the national survey of other water systems. In the second phase, the Northern Arizona University Biology Department will conduct in vitro (test tube) and in vivo (whole body) tests of Flagstaff wastewater effluent to evaluate vertebrate behavior and physiological effects on the endocrine system. The results of the investigations are expected by early 2004.

Microbial Constituents

A wide variety of microbial pathogens may be found in wastewater, including enteric bacteria, enteric viruses, and enteric protozoan parasites.[263] Concerns about microbial constituents in water are nearly exclusively related to the human health hazard associated with acute illnesses and infectious disease. The hazards of waterborne disease have been reduced due to improved sanitary conditions, medical advances, and better

[259] Daughton and Ternes, 1999; Tsuchihashi and others, 2002
[260] Clark, 2001
[261] 2002
[262] Propper, et. al., 2002
[263] Asano, 1998

microbiological and epidemiological methods for identifying outbreaks. Development of large population centers and advancements in civilizations have been directly associated with improvements in managing water supplies and wastewater sanitation.[264] Well-known waterborne diseases, although still important worldwide, have decreased substantially in the United States and other industrialized countries.[265] Enteric (intestinal) pathogens still occur and any potable water supply receiving human or animal wastes can be contaminated with microbial agents. Even pristine water supplies have been linked to disease outbreaks, presumably from wildlife in the watershed. Because Giardia is endemic in wild and domestic animals, infection can result from water supplies that have no wastewater contribution.[266]

Enteric microbial pathogens in wastewater are substantially removed by conventional treatment, although they are not completely eliminated even with disinfection. Fecal coliform bacteria, which are used as an indicator of microbial pathogens, are typically found at concentrations ranging from 10^5 to 10^7 colony-forming units per 100 milliliters (CFU/100 ml) in untreated wastewater. Advanced wastewater treatment may remove as much as 99.9999+ percent of the fecal coliform bacteria; however, the resulting effluent has detectable levels of enteric bacteria, viruses, and protozoa, including Cryptosporidium and Giardia.[267] These data suggest that wastewater discharges are contributing enteric pathogens to ambient surface waters, many of which may be used downstream for drinking purposes. It is now known that most documented outbreaks of waterborne disease in the United States are caused by protozoan and viral pathogens in waters that have met coliform standards.[268]

Wastewater Reuse

Literature Search on the Use of Reclaimed Water for Various Recreational and Municipal Purposes (Indicator)

Reuse of municipal wastewater has become increasingly important during the past several decades due to the growth in urban population, constraints on the development of new water sources, and more stringent treatment requirements to protect the quality of the receiving water for aquatic life. The use of reclaimed water for non-potable purposes can greatly reduce the demand on potable water sources in areas lacking sustainable, high-quality water supplies. Reuse is practiced extensively in the United States and around the world. California, Arizona, and Florida are at the forefront of water reuse.[269] In 1995, for example, the USGS[270] reported that more than one billion gallons per day of reclaimed water were used in the United States; reported use for California and Arizona was 334 and 180 million gallons per day, respectively. Reuse of municipal reclaimed water is presently about 4.8 billion gallons per day in the United States, or about one percent of all freshwater withdrawals.[271]

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[264] Bouwer, 1994
[265] National Research Council, 2003
[266] Id.
[267] Rose and others, 1996
[268] National Research Council, 2003
[269] Solley and others, 1998
[270] Id.
[271] U.S. Department of Energy, 2001

Reclaimed water is most commonly used for non-potable purposes, such as agriculture, landscape irrigation, power plant cooling, industrial processing, dust control, and fire suppression. Other non-potable applications include recreational and environmental uses, ranging from aesthetic ponds and ornamental fountains to full-scale development of water-based recreational sites for swimming, fishing, and boating.[272] Non-potable reuse is a widely accepted practice that will continue to grow.[273]

Although most reclaimed water projects have been developed to meet non-potable water demands, a number of projects use reclaimed water indirectly for potable purposes. These projects include numerous groundwater recharge facilities that have operated successfully for many years to replenish public drinking water supplies.[274] Additional treatment of the reclaimed water occurs during groundwater recharge from natural filtration by the underground sediments and rock formations.[275] The resulting soil-aquifer treatment removes essentially all of the suspended solids and microorganisms that may be present and substantially reduces the concentration of metals, nitrogen, phosphate, ammonia, and dissolved organic compounds in the reclaimed water.[276] Further, although there is only limited research available, a recent study indicates that more than 90 percent of the hormonally active compounds (synthetic organic compounds that can block, mimic, stimulate, or inhibit the production of natural hormones) in wastewater are removed during soil-aquifer treatment, primarily by biodegradation.[277] .

Discussion of Existing Water Rights and the Ability to Implement the Proposed Snowmaking With or Without Procuring Additional Water Rights (Indicator)

The City of Flagstaff has agreed to provide the Snowbowl with up to 1.5 million gallons per day (MGD) of Class A+ reclaimed water for snowmaking purposes from the beginning of November through the end of February each winter. The source of water is the Rio de Flag Water Reclamation Facility (WRF). The contract is for a period of five years. Currently, this same water is used to irrigate City parks and school playgrounds, but is mostly unused in the winter. Treated water that is not reused is discharged to Rio de Flag drainage, where it creates a limited reach of dependent riparian habitat in the normally dry river channel. The extent of surface water downstream from the Rio de Flag WRF is limited by infiltration that occurs via fractures and sink holes in the exposed Kaibab Formation terrain.

In the western United States, the right to use water has developed through a series of federal and state laws and judicial actions. A water right entitles the right-holder to use water; it is not a right of ownership but rather a right of use. The state generally retains ownership of so-called natural or public waters within its boundaries, and state statutes, regulations, and case law govern the allocation and administration of the rights of private

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[272] U.S. Environmental Protection Agency, 2003a
[273] Id.
[274] U.S. Environmental Protection Agency, 2003a
[275] Bouwer et al. 2002
[276] Bouwer et al., 2002a
[277] Zhang et al., 2003

parties and governmental entities to use such water. The main types of water rights in Arizona are surface water and groundwater rights. Each type of right is governed by different laws.

In a semi-arid state, such as Arizona, water rights are often controversial and frequently a matter of legal dispute and intervention. The right to the use of reclaimed water in Arizona is no exception, and was established by the 1989 decision of the Arizona Supreme Court in the case of *Arizona Public Service v. Long*.[278] In this case, the Arizona Supreme Court determined that effluent is neither surface water nor groundwater and cities can put the reclaimed water to any reasonable use they see fit, within existing legislative restrictions. In reaching this decision, reclaimed water was determined not to be subject to regulations under Arizona's surface water or groundwater code. The Court ruled that effluent discharges are subject to appropriation by downstream users, but the cities were not obligated to continue discharge of the effluent to satisfy the needs of downstream appropriators.

The case of *Arizona Public Service v. Long* clarifies the legal basis for the City of Flagstaff to sell reclaimed water for reuse. The use of reclaimed water by the Snowbowl, as well as other customers currently using reclaimed water for irrigation, is not restricted by water rights.

RIO DE FLAG WATER RECLAMATION FACILITY

Description and Quantification of the Rio de Flag Water Reclamation Facility's Historic Seasonal Discharges (Indicator)

The Rio de Flag WRF was constructed in 1992 following a comprehensive evaluation of the City of Flagstaff's future water and sewer needs. At that time, the city's wastewater was treated at the Wildcat Hill Wastewater Treatment Plant (WWTP) in east Flagstaff, which was nearing total design capacity. The Rio de Flag WRF was built to provide four millions gallons per day (MGD) of additional wastewater treatment capacity, with the potential for expansion to six MGD. The plant was designed to provide advanced treatment of wastewater to produce Grade A+ reclaimed water (detailed in the Water Quality of the Rio de Flag WRF section, below) for unrestricted non-potable reuse. This requires, in addition to conventional primary and secondary wastewater treatment, advanced treatment for nitrogen removal, ultraviolet disinfection, and filtration. At the time of construction, the city installed approximately 10 miles of distribution piping for the reclaimed water system, allowing for reclaimed water deliveries to major irrigation and recreation users throughout the city.

Overview of the Rio de Flag WRF Treatment Process

The Rio de Flag WRF receives raw wastewater from the Rio de Flag interceptor sewer at a location where approximately half of the city's sewer flow can be obtained. The process uses screening, primary sedimentation, aeration, secondary sedimentation, filtration, and disinfection.

[278] McGinnis, 1990

In the primary treatment stage, solids settle out as sludge in the primary clarification tanks and are sent to the Wildcat Hill WWTP via sewer pipeline for digestion. Scum and odors are also removed at the primary clarification point. Wastewater is then gravity-fed for secondary treatment through the aeration/denitrification process, where biological digestion of waste occurs. The process used for biological treatment is the Bardenpho Process, in which a two-stage anoxic/aerobic process removes nitrogen, suspended solids, and BOD from the wastewater. The secondary clarifiers remove the by-products generated by this biological process, recycle microorganisms back into the process from return activated sludge, and separate the solids from the waste system. The waste sludge is sent to the Wildcat Hill WWTP for treatment. The water for reuse then passes through the final sand and anthracite filters prior to disinfection by ultraviolet light radiation. At this point, the reclaimed water may be either pumped to a two million gallon reclaimed water tank at Buffalo Park to be gravity-fed into the reclaimed water distribution system, or discharged into the Rio de Flag. Water supplied for reuse is further treated with a hypochlorite solution to assure that residual disinfection is maintained in the reclaimed water system.

Due to the close proximity of the Rio de Flag WRF to the central part of the city of Flagstaff, the plant was designed and constructed to minimize impacts to surrounding land uses. The treatment components are fully enclosed and utilize an activated carbon system to remove odors prior to venting the clean air to the atmosphere.

Pre-treatment Program

The national pretreatment program under the CWA controls the discharge of pollutants to municipal wastewater treatment plants by industrial users. Discharges to treatment plants are regulated primarily by the plant operator, rather than the Federal or State government.

The City of Flagstaff has developed a local pretreatment program to control industrial discharges into the city sewer system. The program has been approved by EPA and ADEQ. As part of the pretreatment program, the Industrial Waste Monitoring Division of the City of Flagstaff Utilities Department monitors various industries that discharge wastewater to the municipal sewer system and specifies local limits, as applicable, for dischargers to assist the city in achieving compliance with its AZPDES permit.

According to sewer use records from January 1999 to April 2001, industrial sources contributed approximately 20 percent of the total inflow to the Rio de Flag WRF.[279] Industrial discharges originate from eight significant industrial users (SIUs) to the city sewers. In a recently-completed Local Limits Study, 23 primary pollutants of concern were identified for the Wildcat Hill WWTP and Rio de Flag WRF.[280] The pollutants include 11 metals and inorganic compounds, eight organic compounds, nitrogen compounds (nitrate and nitrite), and levels of BOD and suspended solids. These pollutants are considered to represent the greatest risk for non-compliance with permit limitations for discharges under the City's AZPDES permit and APP. Pollutants of concern are identified by evaluating the chemicals present in waste streams from the SIUs, the background levels of the chemicals present in natural waters and non-industrial

[279] Malcolm Pirnie, 2002

[280] Id.

sources, the efficiency of the city wastewater treatment plants to remove the pollutants, and analysis of relevant regulatory numerical discharge limits. Lastly, although discharges of non-industrial pollutants are difficult to characterize, key non-industrial pollutants, such as pesticides, nitrogen, and volatile organic compounds that present concerns for fire and explosion hazards in the collection system, are included as pollutants of concern.

The Rio de Flag WRF has treated wastewater at an average rate of 681 million gallons per year (1.87 MGD) during the past four years. The most recent data from 2002 indicate that approximately 25 percent of the wastewater treated at the WRF was beneficially reused in the Reclaimed Water System and 75 percent was discharged as Grade A+ treated effluent to the Rio de Flag channel. The reuse is highly seasonal; two thirds of the reuse occurs from May through August, when the average demand for reclaimed water has been about one MGD. In 2003, demand for reclaimed water increased to nearly two MGD due to the opening of the Pine Canyon Golf Course. In contrast, only about 55,000 gallons per day of reclaimed water were used in the winter months of November through February, representing only four percent of the City's annual water reuse from the Rio de Flag WRF.

Description and Quantification of Current Uses of Reclaimed Water Within the City of Flagstaff by Season (Indicator)

The Rio de Flag WRF currently provides reclaimed water for turf irrigation to the Catholic Cemetery; Northern Arizona University; Pine Canyon Golf Course; Flagstaff Medical Center; the Flagstaff public school system; and the city's public parks, facilities, and cemetery. Reclaimed water from the Wildcat Hill WWTP is used for irrigation at golf courses, public parks, and the Christmas tree farm, and for dust control at various locations in east Flagstaff.

WATER QUALITY OF THE RIO DE FLAG WRF

Discussion of the Applicability of the Rio De Flag WRF NPDES Permit to the Proposed Snowmaking Application (Indicator)

Description of the Certification Process for Allowing Class A Water to be Used for Snowmaking (Indicator)

The regulatory programs governing reclaimed water reuse have been developed in a risk-based framework to protect public health and minimize the hazards associated with potential exposures. ADEQ developed the Reclaimed Water Permit Program to define conditions and requirements for reuse of treated municipal wastewater. The program specifies reclaimed water standards and defines five classes of reclaimed water. Class A reclaimed water is the highest quality and is required for reuse applications where there is a relatively high risk of human exposure to treated effluent. For uses where the potential for human exposure is lower, Class B and Class C reclaimed water are acceptable. The Reclaimed Water Quality Standards include two "+" categories of reclaimed water, Class A+ and Class B+. The "+" designation indicates that treatment is used to decrease the total nitrogen concentration to less than 10 mg/L in the reclaimed water. Wastewater treatment facilities providing reclaimed water for reuse must identify the class of reclaimed water generated by the facility.

The use of reclaimed water for snowmaking was originally studied as a means of storing effluent during winter when land application was not feasible. Studies and full-scale use of reclaimed water in snowmaking have been conducted in Colorado, Michigan, and Maine. The site studies showed that converting wastewater to snow improved its quality upon melting and subsequent discharge to surface waters. Snowmelt from reclaimed water exhibited a substantial reduction in nutrients, BOD, and suspended solids.[281] According to studies conducted by the U.S. Army Corps of Engineers,[282] the process of freezing and repeated freeze-thaw cycles also destroy bacteria in reclaimed water. Results indicated that more than 99.9 percent of the total coliform bacteria and more than 99 percent of the fecal coliform bacteria were removed in the snowmelt from a non-chlorinated secondary wastewater effluent supply used in snowmaking. Other species of bacteria were affected less. The studies also found that many species of bacteria survived the multiple freeze-thaw cycles and reproduced in the resultant snowmelt. Furthermore, much of the snowmelt infiltrated into the ground, where additional soil-aquifer treatment and contaminant removal occurred before groundwater was discharged into streams.

The use of reclaimed water for snowmaking at commercial skiing operations is beginning to gain recognition. Reclaimed water for snowmaking has been proposed as a method of supplementing snowmaking at ski areas throughout the eastern United States[283] and in Australia.[284] Reclaimed water has been used to make snow since 1985 at the Seven Springs Mountain Resort, located southeast of Pittsburgh, Pennsylvania. Seven Springs has an extensive snowmaking system that is supplemented with up to 600,000 gallons per day of reclaimed water.[285] Reclaimed water used for snowmaking at Seven Springs is gray water derived from wastewater treatment lagoons. The gray water is discharged to a series of ponds, which receive water from springs and on-site stormwater runoff prior to reuse applications. Effluent is also used at the resort in the summer for golf course irrigation.

The State of Arizona allows Class A and A+ reclaimed water for direct reuse in snowmaking. Due to the relatively high risk of human exposure to potential contaminants in reclaimed water, ADEQ has developed strict and specific treatment requirements for reuse applications having higher degrees of public contact, such as skiing, that include secondary treatment, filtration, and disinfection. In meeting these requirements, the reclaimed water is considered acceptable for unrestricted recreational use.

All wastewater treatment facilities providing reclaimed water for reuse must have an Individual Aquifer Protection Permit (APP), or amend their existing APP to contain certification for a particular class of reclaimed water. The Rio de Flag WRF operates under a 1997 APP[286] that was reissued with Significant Amendment in April, 2002. The APP was amended to classify the Rio de Flag WRF for production of Class A+ reclaimed

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[281] Wright Water Engineers, 1988; Wright-Pierce Engineers, 1999; Maine Lagoon Task Force, 2003

[282] Parker and others, 2000

[283] U.S. Environmental Protection Agency, 1992

[284] Tonkovic and Jeffcoat, 2002; ABC Online, 2003

[285] S. Eutsey, personal communication

[286] APP P-102421

water. The amended APP allows the city to operate the Rio de Flag WRF with a maximum average monthly flow of 4.0 MGD and reuse effluent under a Reclaimed Water Individual Permit[287] that was issued in May 2002. The APP is valid for the life of the facility and the Reclaimed Water Permit must be renewed every five years.

Documentation of Compliance with State and Federal Water Quality Standards Regarding Class A Wastewater and its Uses (Indicator)

The Rio de Flag WRF is authorized to discharge treated wastewater to the Rio de Flag under NPDES Permit[288] (currently referred to as an AZPDES Permit since the program has been delegated to State authority) that was issued in November 1999. Effluent limitations and monitoring requirements are specified for a wide variety of conventional wastewater treatment parameters, trace metals, organic chemicals, and priority pollutants. Additionally, the discharge is periodically monitored for chronic toxicity by prescribed whole effluent toxicity (WET) tests. The WET test replicates, to the greatest extent practicable, the actual environmental exposure of aquatic life to the aggregate toxic effects of a wastewater discharge.[289]

The AZPDES Permit requires that water quality of the reclaimed water meet State Surface Water Quality Standards (SWQS) for discharge to the Rio de Flag. The Arizona Department of Environmental Quality (ADEQ) has assigned designated uses of partial-body contact (PBC) and aquatic and wildlife for effluent-dependent water (A&Wedw) to the receiving waters of the Rio de Flag WRF.

More than 40 years of experience in water reuse has led to formulation of guidelines, rules, and water quality standards for a variety of reuse applications. Arizona, together with California and Florida, are among the few states that have developed enforceable programs and specific requirements for treatment, treatment reliability criteria, and water quality standards for various reuse applications to protect public health and the environment.[290] The level of treatment and water quality criteria are based on the expected degree of contact with reclaimed water by the public and aquatic animals and plants.

As noted in the previous sections, the Rio de Flag WRF has three water permits that govern wastewater reclamation, reuse, and facility discharges. The ADEQ administers these permits.

Monitoring data for the AZPDES Permit is submitted in monthly Discharge Monitoring Reports (DMRs) to ADEQ. Monthly DMRs for 2001 and 2002 were reviewed to document compliance with the permit terms and conditions. All regulated parameters in the reclaimed water met established numerical limits for designated uses of PBC and A&Wedw assigned to the Rio de Flag. The reclaimed water also met the numerical criteria for all protected end uses of Arizona surface water, including designated uses with much more restrictive criteria than PBC and A&Wedw.

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[287] R-102421

[288] AZ0023639

[289] U.S. Environmental Protection Agency, 2003b

[290] National Research Council, 2003

EPA and ADEQ conduct annual inspections of the Rio de Flag WRF to assure the facility is operated and maintained in compliance with Federal and State regulations. NPDES inspection reports obtained for the past four years indicate that no deficiencies were found in the operation and maintenance of the Rio de Flag WRF.

Monitoring data for the APP and the Reclaimed Water Permit is submitted to ADEQ in quarterly Self-Monitoring Report Forms (SMRFs). Quarterly SMRFs obtained for 2001 and 2002 indicate full compliance with permit terms and conditions. All regulated parameters in the reclaimed water met established numerical limits for Aquifer Water Quality Standards, which are equivalent to EPA Primary Drinking Water Standards. Additionally, of the enteric viruses or parasites tested in reclaimed water, none have been detected.

ADEQ was interviewed to appraise the Rio de Flag WRF operations and confirm the facility compliance status. In a letter dated September 9, 2003, ADEQ stated that its review of the facility file and existing information in the wastewater compliance, enforcement, and tracking database indicates the Rio de Flag WRF is in compliance with the APP and the AZPDES Permits. Further discussions with the Northern Regional Office, Water Permits Section, and Water Quality Compliance Section of the ADEQ Water Quality Division confirmed there were no known compliance issues or operating concerns associated with the Rio de Flag WRF. ADEQ staff openly commended the exemplarily performance of the Rio de Flag WRF and City of Flagstaff Utilities Division.

ENVIRONMENTAL CONSEQUENCES

SUMMARY OF ENVIRONMENTAL CONSEQUENCES AND CONCLUSIONS

Major conclusions and determinations of this Watershed Resources analysis are summarized below. A more detailed analysis of the direct and indirect environmental consequences – from which this summary was derived – follows.

Direct Effects

The proposed snowmaking and facility improvements considered in Alternative 2 would have the net effect of increasing groundwater recharge and solute concentrations in groundwater in the areas where snowmaking would be implemented. Under dry year or wet year less overall groundwater recharge – attributable to the applied snowmaking – would result than those calculated for average precipitation conditions. Groundwater recharge occurring in areas of proposed snowmaking would contain larger concentrations of TDS, TOC, total nitrogen, and other dissolved constituents from the reclaimed water than groundwater recharge from natural precipitation. However, the solute concentrations would be decreased substantially from concentrations in the reclaimed water by commingling and blending with natural precipitation. For example, projected average concentrations of TDS and TOC in recharge in the Snowbowl sub-area, where more than 90 percent of the snowmaking activity would take place, are projected to be reduced by a factor of four from reclaimed water concentrations.

Although the proposed implementation of Alternative 2 would increase the amount of groundwater recharge and solute concentrations in groundwater recharge in the immediate vicinity of the Snowbowl, it would not comprise a direct impact on any groundwater users or potential receptors in the Snowbowl sub-area or Agassiz sub-watershed because there are no wells, springs, or other discharges of groundwater in these areas.

The proposed facilities improvements associated with Alternative 3 would not have any consequential direct effects on groundwater recharge or groundwater water quality in the Snowbowl sub-area or the Agassiz sub-watershed.

Indirect Effects

The net effects of additional groundwater recharge and water quality changes from the use of reclaimed water for snowmaking over time may potentially comprise an indirect effect on groundwater users or potential receptors that are outside the immediate areas of proposed snowmaking in Hart Prairie. Snowmaking and associated additional groundwater recharge may potentially increase groundwater availability and the concentration of solutes in groundwater downgradient from the Snowbowl. The nearest known groundwater users and potential receptors are the private wells, springs, and stock tanks in Hart Prairie. As shown in Figure 3H-1, the wells, springs, and stock tanks are located more than 3,500 feet west and down slope from the nearest areas of proposed snowmaking at the Snowbowl.

Due to the complex movement of groundwater through the Sinagua formation and underlying volcanic deposits in this area, it is difficult to specifically determine the sources of shallow groundwater for the perched aquifers in the Hart Prairie area. Therefore, the degree to which any change in groundwater availability or water quality resulting from implementation of Alternative 2 actions would impact the wells, springs, and stock tanks in this area can not be projected with certainty. Consequently, the potential contribution and effect of any additional recharge from areas of snowmaking to specific potential receptors in Hart Prairie can not be precisely projected. However, the projections of groundwater recharge and water quality impacts for the Hart Prairie watershed discussed can provide a conceptual approximation of the potential magnitude of impacts to groundwater users in this area. Based on these projections, the snowmaking proposed in Alternative 2 may contribute a minor amount of groundwater to underlying aquifers, including the perched aquifers in the Hart Prairie watershed. The additional groundwater could possibly benefit groundwater users and other potential receptors, such as wildlife and vegetation that are supported by the shallow perched groundwater system and small springs and associated seeps. The overall effect, however, is not expected to be significant due to the small incremental increase to water supply, which is on the order of five percent of the projected existing Hart Prairie groundwater recharge, in years of average precipitation.

While the water quality impact to downgradient groundwater users in Hart Prairie can not be projected with any certainty, it is clear there would be substantial attenuation of solute concentrations as the reclaimed water in artificial snow combines with natural precipitation, infiltrates from the area of snowmaking, and blends with other groundwater recharge and groundwater in storage as it moves downgradient to the perched aquifers underlying Hart Prairie. It is expected that certain nutrients and dissolved organic constituents in reclaimed water would be removed though physical, chemical, and biological uptake during infiltration in surficial soils and underlying sediments. Based on calculations of blending and resulting chemical quality of water projected to be available for groundwater recharge in the Hart Prairie watershed, there may be more than an order of magnitude decrease in concentration of solutes, such as TDS and TOC, from the reclaimed water used in snowmaking to the resulting groundwater underflow to the Hart Prairie watershed. Consequently, although there could be potential increases of dissolved salts and other constituents of reclaimed water in groundwater downgradient from the areas of snowmaking, the water quality impact is likely to be limited due to the substantial extent of groundwater recharge resulting from yearly precipitation in all but the driest climatic conditions throughout Hart Prairie and the upper sub-watersheds compared to that derived from proposed snowmaking.

DETAILED ANALYSIS OF DIRECT AND INDIRECT EFFECTS

Quantification of Anticipated Annual Water Use

Issue:

Use of reclaimed water for snowmaking purposes between November and February of each year could affect aquifer recharge.

Indicators:

Quantification Of Anticipated Snowmaking Water Use in Average Dry, Median, and Wet Years

Quantification of Anticipated Total Consumptive Water Losses (i.e., Evaporation, Evapotranspiration, Sublimation) Resulting from Proposed Snowmaking

Direct and indirect environmental consequences for the three alternatives were evaluated by projecting hydrologic conditions for average, dry, and wet climatic conditions based on calculations of precipitation, snowmaking water use, watershed losses, and groundwater recharge, and by making assumptions for chemical quality of reclaimed water and natural precipitation.

Direct impacts of the proposed use of reclaimed water for snowmaking were estimated by calculating and comparing the volume and chemical quality of groundwater recharge projected to occur in the immediate proximity of snowmaking areas (Snowbowl sub-area and Agassiz sub-watershed, shown on Figure 3H-1).

Indirect impacts were determined by calculating and comparing the volume and chemical quality of groundwater recharge that is assumed may potentially impact users of groundwater yielded from wells, seeps, or springs in the watersheds that receive groundwater underflow from the snowmaking areas of the Snowbowl sub-area.

Projected hydrologic conditions under all three alternatives for the Snowbowl sub-area, Agassiz sub-watershed, and the Hart Prairie watershed are given in Tables 3H-1, 3H-2, and 3H-3.

Alternative 1 – No Action

Under the No Action Alternative, implementation of snowmaking infrastructure would not occur, and current conditions as presented above would be expected to persist. No machine-produced snow would be applied within the project area.

Alternative 2 – The Proposed Action

Under the Proposed Action, a total of 205.2 acres of snowmaking terrain would be implemented at the Snowbowl. This terrain would be primarily implemented within the Snowbowl Sub-area, with smaller acreages implemented in other proximal watersheds.

The depth of snow that would be initially produced on existing and proposed terrain would result in an average coverage depth across all terrain types of slightly more than 25 inches of snow. Estimated operational conditions under the varying climatic scenarios are outlined as follows:[291]

1. Once all the trails have been covered with the specified depth of snow, resurfacing operations would typically commence to recover from any thaws and replenish snow that has become hardened through wear and temperature cycling. The amount of resurfacing required would depend on natural snowfall. In a wet year, it is estimated that only the initial application would be required. This application could be spread out over the season if there was abundant snow early in the year, or it could be concentrated at the beginning of the season if the bulk of the snow arrives after December.

2. On an average year, it is estimated that an additional half-application of machine-produced snow would be required after the initial coverage for a seasonal total of 1.5 coverages.

3. On a dry year, it is estimated one additional full application of machine-produced snow would be required after the initial coverage for a seasonal total of two coverages.

<u>Snowbowl Sub-area</u>

The reader is referred to Table 3H-1 for this discussion of hydrologic impacts to the Snowbowl Sub-area.

Average Precipitation Years

The Proposed Action would likely have the net effect of increasing groundwater recharge in the areas where snowmaking would be implemented. In average years, the proposed snowmaking operations in Alternative 2 are estimated to contribute approximately 187 AF of additional recharge within the Snowbowl sub-area. This snowmaking contribution represents an increase of approximately 14 percent when compared to the average

[291] Sno.matic, 2003.

volume of natural groundwater recharge estimated to occur in this very limited area of San Francisco Mountain.

Low Precipitation Years

In dry years, when snowmaking is increased, the available water for recharge is substantially decreased due to increased atmospheric losses from evaporation, evapotranspiration, and sublimation in the watershed; snowmaking would contribute a larger fraction of the total recharge, although less water in absolute terms. Table 3H-1 indicates that in the dry-year precipitation analysis, approximately 31 AF of additional water is estimated to be available for recharge due to snowmaking operations; this volume represents a 22-percent increase in recharge from estimated natural ground water recharge.

Above-Average Precipitation Years

In wet years, when snowmaking is not as necessary, much more snowmelt is available to recharge and it contains a substantially smaller proportion of machine-produced snow than in dry and average years. Estimated water losses would comprise a smaller fraction of the available precipitation; therefore, the additional estimated recharge contributed from snowmaking is a smaller fraction of the total estimated recharge. In the wet-year case, approximately 146 AF of additional water is estimated to be available for recharge due to snowmaking operations; this volume represents a five percent increase in recharge from estimated natural ground water recharge.

Table 3H-1
Projected Hydrologic Conditions in the Snowbowl Sub-Area

	Area (Acres)	Pptn (AF/yr)	Snow-making (AF/yr)	Watershed Loss (AF/yr)	Recharge (AF/yr)	Diff. in Recharge compared to Existing (AF/yr)	Projected Groundwater Concentrations			Projected Mass Loading		
							TDS (mg/L)	TOC (mg/L)	Nitrogen (mg/L)	TDS (kg/ha)	TOC (kg/ha)	Total N (kg/ha)
DRY YEAR												
Existing Conditions	1,060.8	1,190.2	0	1,057.5	140.9	--	25.3	0.0	4.2	10.3	0.0	1.7
Alternative 2	1,060.8	1,190.2	446	1,464.1	172.1	*+31.2*	901.9	20.7	19.0	445.9	10.3	9.4
Alternative 3	1,060.8	1,190.2	0	1,033.8	164.7	*+23.8*	21.7	0.0	3.6	10.3	0.0	1.7
AVERAGE YEAR												
Existing Conditions	1,060.8	2,892.0	0	1,545.6	1,346.4	--	6.4	0.0	1.1	24.9	0.0	4.2
Alternative 2	1,060.8	2,892.0	334	1,692.9	1,533.2	*+186.8*	79.7	1.7	2.3	351.2	7.7	9.9
Alternative 3	1,060.8	2,892.0	0	1,522.9	1,369.1	*+22.7*	6.3	0.0	1.1	24.9	0.0	4.2
WET YEAR												
Existing Conditions	1,060.8	4,408.0	0	1,604.4	2,803.6	--	4.7	0.0	0.8	38.0	0.0	6.3
Alternative 2	1,060.8	4,408.0	223	1,681.7	2,949.2	*+145.6*	30.2	0.6	1.2	255.8	5.1	10.2
Alternative 3	1,060.8	4,408.0	0	1,581.9	2,826.1	*+22.5*	4.7	0.0	0.8	38.0	0.0	6.3

Notes: Assumes reclaimed water has: 340 mg/L TDS, 8 mg/L TOC, and 6 mg/L total nitrogen
Assumes precipitation has: 3 mg/L TDS, 0 mg/L TOC, and 0.5 mg/L total nitrogen
Assumes all solute mass is conserved; therefore, solutes are concentrated as watershed losses occur

Pptn = precipitation TDS = total dissolved solids mg/L = milligrams per liter AF/yr = acre feet per year TOC = total organic carbon kg/ha = kilograms per hectare
N = Nitrogen

Agassiz Sub-Watershed

For the Agassiz sub-watershed (Table 3H-2), the proposed snowmaking operations are estimated to contribute no additional groundwater recharge in average, dry, or wet years. Compared to existing conditions, the volume of recharge for Alternative 2 is estimated to be roughly seven AF (one percent) *less* in an average year, essentially no change in a dry year, and 47 AF (three percent) less in a wet year. The decrease in recharge is due to the fact that the snowmaking component is minor (less than 10 percent of planned coverage) in the Agassiz sub-watershed with other ground-disturbing activities would result in net watershed losses.

Table 3H-2
Projected Hydrologic Conditions in the Agassiz Sub-Watershed

	Area (Acres)	Pptn (AF/yr)	Snow-making (AF/yr)	Watershed Loss (AF/yr)	Recharge (AF/yr)	Diff. in Recharge Over Existing (AF/yr)	Projected Groundwater Concentrations		
							TDS (mg/L)	TOC (mg/L)	Total N (mg/L)
DRY YEAR									
Existing Conditions	768.8	790.1	0	790.1	0.0	--	NA	NA	NA
Alternative 2	768.8	790.1	40	830.2	0.0	-0.1	NA	NA	NA
Alternative 3	768.8	790.1	0	790.1	0.0	0	NA	NA	NA
AVERAGE YEAR									
Existing Conditions	768.8	1,919.9	0	1,240.1	679.9	--	8.5	0.0	1.4
Alternative 2	768.8	1,919.9	30	1,276.7	673.2	-6.7	23.7	0.4	1.7
Alternative 3	768.8	1,919.9	0	1,260.6	659.3	-20.6	8.7	0.0	1.5
WET YEAR									
Existing Conditions	768.8	2,926.3	0	1,283.9	1,642.4	--	5.3	0.0	0.9
Alternative 2	768.8	2,926.3	20	1,350.9	1,595.4	-47.0	9.8	0.1	1.0
Alternative 3	768.8	2,926.3	0	1,330.5	1,595.8	-46.6	5.5	0.0	0.9

Notes: Assumes precipitation has: 3 mg/L TDS, 0 mg/L TOC, and 0.5 mg/L total nitrogen
Assumes all solute mass is conserved; therefore, solutes are concentrated as watershed losses occur

Pptn = precipitation TDS = total dissolved solids mg/L = milligrams per liter AF/yr = acre feet per year
TOC = total organic carbon kg/ha = kilograms per hectare N = Nitrogen

Hart Prairie Watershed

As noted, indirect effects from snowmaking activities associated with the Proposed Action may potentially impact the surrounding areas down slope from the Snowbowl SUP area, including: 1) Hart Prairie, with four small springs and associated seeps and a number of shallow wells yield groundwater from shallow perched aquifers; and 2) along the southwest flank of Agassiz Peak, where four small springs yield groundwater from shallow perched aquifers. Hart Prairie is the primary area of indirect effects because it is in the watershed that receives infiltration from more than 90 percent of the snowmaking areas.

The nearest known groundwater users and potential receptors are the private wells, springs, and stock tanks in Hart Prairie that are more than 3,500 feet downgradient from the area of proposed snowmaking. The reader is referred to Table 3H-3. Implementation of Alternative 2 may contribute a minor amount of groundwater to underlying aquifers including the perched aquifers in the Hart Prairie watershed. Because recharge infiltrates rapidly to underlying aquifers, and the local recharge near the springs is projected to be sufficient to provide the observed discharge, it is not known if any groundwater recharge from the areas of snowmaking reaches the shallowest perched aquifers down slope at the springs in Hart Prairie. However, to the extent it does contribute to discharge at the springs, the additional recharge from Alternative 2 would benefit groundwater users and other potential receptors, such as wildlife and vegetation that are supported by the shallow perched groundwater system and small springs and associated seeps. The overall effect, however, is not expected to be significant due to the small incremental increase to water supply, which is on the order of five percent of the projected existing Hart Prairie groundwater recharge, in years of average precipitation.

Average Precipitation Year

In an average precipitation year, the proposed snowmaking activity in the Proposed Action is projected to contribute approximately 187 AF of additional groundwater recharge from the Snowbowl sub-area within the Hart Prairie watershed. This recharge contribution represents an increase of more than four percent to the volume of groundwater recharge projected to occur due to infiltration of natural precipitation in the Hart Prairie watershed in average precipitation years.

Below Average Precipitation Year

In the dry-year case, approximately 31 AF of additional groundwater recharge is attributed to Alternative 2 activities; this volume is an increase of roughly 13 percent from the projected existing conditions.

Above Average Precipitation Year

In the wet-year case, roughly 237 AF of additional recharge is projected to occur in the Hart Prairie Watershed; this volume is an increase of roughly 2.5 percent from existing conditions.

Table 3H-3
Projected Hydrologic Conditions in the Hart Prairie Watershed

	Area (Acres)	Pptn (AF/yr)	Snow-making (AF/yr)	Watershed Loss (AF/yr)	Recharge (AF/yr)	Diff. in Recharge Over Existing (AF/yr)	Projected Groundwater Concentrations TDS (mg/L)	TOC (mg/L)	Total N (mg/L)
DRY YEAR									
Existing Conditions	4,249.9	4,353.8	0	4,125.5	236.6	--	55.2	0.0	9.2
Alternative 2	4,249.9	4,353.8	446	4,532.1	267.7	31.1	615.2	13.3	18.1
Alternative 3	4,249.9	4,353.8	0	4,101.8	260.3	23.7	50.2	0.0	8.4
AVERAGE YEAR									
Existing Conditions	4,249.9	10,579.1	0	6,295.4	4,283.7	--	7.4	0.0	1.2
Alternative 2	4,249.9	10,579.1	334	6,442.6	4,470.5	186.8	32.5	0.6	1.6
Alternative 3	4,249.9	10,579.1	0	6,272.7	4,306.4	22.7	7.4	0.0	1.2
WET YEAR									
Existing Conditions	4,249.9	16,124.5	0	6,583.5	9,540.9	--	5.1	0.0	0.8
Alternative 2	4,249.9	16,124.5	223	6,569.2	9,778.2	237.3	12.7	0.2	1.0
Alternative 3	4,249.9	16,124.5	0	6,561.0	9,563.4	22.5	5.1	0.0	0.8

Notes: Assumes precipitation has: 3 mg/L TDS, 0 mg/L TOC, and 0.5 mg/L total nitrogen
Assumes all solute mass is conserved; therefore, solutes are concentrated as watershed losses occur

AF/yr = acre feet per year
TDS = total dissolved solids
Pptn = precipitation
TOC = total organic carbon
N = nitrogen
mg/L = milligrams per liter

Alternative 3

Proposed vegetation and soil disturbance associated with Alternative 3 would result in a slight calculated difference in watershed losses compared to the existing conditions. In the Snowbowl sub-area, the proposed Alternative 3 improvements are projected to result in approximately one to two percent decrease in atmospheric losses and a corresponding increase in recharge in an average precipitation year. Overall, changes of this limited magnitude are not expected to have any consequential impacts on environmental or hydrologic conditions with respect to the water resource issues.

Snowbowl Sub-Area

Without the addition of snowmaking, Alternative 3 would contribute less additional ground water recharge than the Proposed Action in average, dry, and wet years. As indicated Table 3H-1, in the average year analysis, roughly 23 AF of additional water is estimated to be available for recharge; this volume represents a 1.7-percent increase in recharge from estimated existing conditions. Increases during dry and wet years are estimated to be about 17 percent and about one percent, respectively.

Agassiz Sub-Watershed

The facilities improvements proposed without snowmaking in Alternative 3 have about the same effect as Alternative 2 on estimated volumes of groundwater recharge in dry and wet years (Table 3H-2), and provide less recharge than Alternative 2 in an average year.

Water quality and use of reclaimed water in the snowmaking system.

Issue:

The application of Class A reclaimed water for snowmaking within the SUP area may affect water quality within the receiving sub-watersheds.

Indicators:

Analysis of Potential Water Quality Effects Of Using Reclaimed Water in the Snowmaking System to Downgradient Users

Alternative 1 – No Action

Under the No Action Alternative, no new construction or watershed modification would occur. Present hydrogeologic conditions would effectively continue during the planning horizon of this document.

Alternative 2 – The Proposed Action

Recharge estimates from simulated hydrologic conditions for average, dry, and wet years were used to project effects on water quality from snowmaking operations. Projected concentrations of total dissolved solids (TDS), total organic carbon (TOC), and total nitrogen in groundwater recharge are given in tables 3H-1 and 3H-2. Projected concentrations were calculated as the weighted average of reported concentrations of these solutes in reclaimed water from the Rio de Flag WRF and precipitation in northern Arizona. Solute concentrations in the source waters are conserved in the mixing calculation and are assumed to be completely retained in the resulting groundwater recharge. Therefore, it is assumed that, although water is lost from the source waters via evapo-sublimation, etc., all of the solute mass in the source waters remains in the resulting recharge. Table 3H-1 also shows the projected mass loading of solutes in annual groundwater recharge within the Snowbowl Sub-area expressed as kilograms per hectare (kg/ha).

This analysis projects solute concentrations only in the water *available* for groundwater recharge. It does not project the absolute solute concentrations in groundwater *resulting from* recharge because: 1) it neglects the complex biogeochemical processes that occur and result in losses and uptake of solutes during interaction with vegetation, soils, and underlying sediments; and 2) there are no data to estimate the seasonal volumes of perched groundwater available to commingle and blend with the recharge water. It is well documented that nutrients and dissolved organic matter are assimilated to varying degrees during infiltration and percolation of water through soil and sediments. Therefore, this analysis provides a conservative, semi-quantitative assessment of potential dilution and attenuation, over large areas, of solute concentrations from reclaimed water when combined with natural precipitation in groundwater recharge and the available amounts of solutes for uptake or migration into groundwater.

TDS was evaluated as a general indicator of inorganic water chemistry and potential changes that may occur in concentrations of inorganic solutes when combined with snowmelt from artificial snow and natural precipitation in the study area watersheds. For the purpose of water quality projections, the TDS concentration in reclaimed water was assumed to be a constant 340 milligrams per liter (mg/L). Actual TDS concentrations in reclaimed water from the Rio de Flag WRF are somewhat variable depending on several factors, including the water sources used for municipal supply by the City of Flagstaff. The City provided TDS concentrations detected in laboratory chemical analyses for nine samples of reclaimed water obtained from the Rio de Flag WRF from 1993 to 2001. The TDS concentrations ranged from 320 to 360 mg/L; average concentration was 341 mg/L. While data is insufficient to precisely assess seasonal variability, there appears a trend toward higher TDS concentrations in summer than in winter.

Reported TDS concentrations available for natural precipitation in northern Arizona are sparse, and there is no such data for the Snowbowl area. However, data for chemical quality of natural precipitation are available for snow samples obtained from the Mogollon Rim in north-central Arizona and for snow and rainfall samples obtained at the South Rim of Grand Canyon as part of the National Atmospheric Depositional Program.[281] Based on these data, the TDS concentration in natural precipitation at the Snowbowl was assumed to be 3 mg/L.

TOC was evaluated as a general indicator of the dissolved component of organic matter and wastewater compounds and potential changes that may occur in TOC concentrations when combined with natural precipitation. This evaluation did not consider the interaction of dissolved TOC in soils and the subsurface environment which may remove organics through complexation or other physical and chemical processes. TOC is considered in this analysis because it is becoming more common as a surrogate measure of gross organic content and as a practical indicator of the presence of many unidentified and unregulated residual organic contaminants in reclaimed water.[282] For the purpose of water quality projections, TOC concentration in reclaimed water was assumed to be a constant 8.0 mg/L. Actual TOC concentration in reclaimed water is variable. TOC concentrations were detected in laboratory chemical analyses for 19 samples of reclaimed water obtained from the Rio de Flag WRF from 1993 to 2001. The TOC concentrations ranged from 1.7 to 17 mg/L; average concentration was 7.8 mg/L. Data are insufficient to assess seasonal variability

Natural precipitation in Alpine environments is not expected to contain significant concentrations of TOC. Studies[283] indicate that small concentrations (in the magnitude of 20 micrograms per liter) of the organic ions, acetate and formate, were detected in snow throughout the Mogollon Rim and larger concentrations have been reported for snow near major population centers. For the purpose of water quality projections, the TOC concentration in precipitation in the Snowbowl area was assumed to be zero.

Total nitrogen was evaluated as a general indicator of nutrient loading from the presence of nitrogen- and phosphorous-based compounds in reclaimed water and potential changes in concentration when combined with natural precipitation. This evaluation did not consider biological uptake, bacterial decomposition, or other nitrogen removal mechanisms. For the purpose of water quality projections, total nitrogen concentration in reclaimed water was assumed to be 6.0 mg/L. Actual total nitrogen concentration in reclaimed water from the Rio de Flag WRF is measured monthly and reported in

[281] NADP, 2003

[282] McEwen and Richardson, 1996; Crook and Sakaji, 2000

[283] Barbaris and Betterton, 1994

quarterly SMRFs submitted to ADEQ for APP compliance. In 2002, total nitrogen concentration ranged from 4.1 to 6.6 mg/L in samples obtained from the reclaimed water. Most of the nitrogen detected was in the form of nitrate, which ranged in concentration from 3.1 to 5.0 mg/L (as nitrogen). Smaller amounts of nitrogen are present as ammonia and other inorganic and organic nitrogen compounds.

Nitrogen in the form of nitrate and ammonium ions is present at trace concentrations in natural precipitation. According to 2002 NADP precipitation data, the average nitrate and ammonium concentrations were 1.26 mg/L and 0.31 mg/L, respectively. Data collected at the NADP site at the South Rim of Grand Canyon indicates an increasing trend in nitrogen ion species since testing began in 1981. Based on the 2002 data, the total nitrogen concentration in precipitation was assumed to be 0.5 mg/L (as nitrogen).

The proposed implementation of Alternative 2 and additional groundwater recharge associated with use of reclaimed water for snowmaking would increase the concentration of solutes in groundwater. Groundwater recharge that occurs in areas of proposed snowmaking would contain larger concentrations of TDS, TOC, total nitrogen, and other dissolved constituents from the reclaimed water than groundwater recharge from natural precipitation. However, the solute concentrations would be decreased substantially from concentrations in the reclaimed water by commingling and blending with natural precipitation. For example, projected average concentrations of TDS and TOC in recharge in the Snowbowl sub-area, where more than 90 percent of the snowmaking activity is proposed to take place, would be reduced by a factor of four from reclaimed water concentrations.

The additional solute contribution from the reclaimed water used for snowmaking would increase the concentration of solutes in groundwater recharge that occurs in the Hart Prairie watershed. However, the water quality impact to downgradient groundwater users in Hart Prairie can not be projected with any certainty. As described above, it is not known if any groundwater recharge originating in the vicinity of the Snowbowl and areas of proposed snowmaking contributes to the discharge from springs in Hart Prairie; most or all of it may infiltrate to the deeper perched aquifers in Hart Prairie before it reaches the spring areas. It is expected, though neglected in the quantitative projections of impact, that certain nutrients and dissolved organic constituents in reclaimed water would be removed though physical, chemical, and biological uptake during infiltration in surficial soils and underlying sediments. It is also clear there would be substantial attenuation of solute concentrations as the reclaimed water in artificial snow combines with natural precipitation, infiltrates from the area of snowmaking, and blends with other groundwater recharge and groundwater in storage as it moves downgradient to the underlying perched aquifers. Based on calculations of blending and resulting chemical quality of water available for groundwater recharge in the Hart Prairie watershed, there may be more than an order of magnitude decrease in concentration of solutes, such as TDS and TOC, from the reclaimed water used in snowmaking to the resulting groundwater recharge in the Hart Prairie area. Consequently, although there could be potential increases of dissolved salts and other constituents of reclaimed water in groundwater downgradient from the areas of snowmaking, the water quality impact is not likely to be significant due to the substantial extent of recharge that occurs in all but the driest climatic conditions throughout Hart Prairie and the upper sub-watersheds compared to that derived from proposed snowmaking.

Snowbowl Sub-area

Table 3H-1 gives the TDS, TOC, and total nitrogen concentrations and mass loading projected for groundwater recharge in the Snowbowl sub-area for Alternative 2. For an average precipitation year, the projected TDS concentration is about 80 mg/L, TOC concentration is 1.7 mg/L, and total nitrogen concentration (as nitrogen) is 2.3 mg/L. Average precipitation yields an estimated mass loading of about 350 kg/ha for TDS, 8.0 kg/ha for TOC, and 10 kg/ha for total nitrogen (as nitrogen).

It is important to re-emphasize that these projections are neither absolute nor anticipated concentrations in groundwater because: 1) varying biological, chemical, and physical processes modify solute concentrations as groundwater interacts with vegetation, soils, and subsurface sediments; and 2) there are no data to estimate seasonal volumes of perched groundwater available to commingle and blend with the recharge water. The practical value of these projections is to provide a semi-quantitative assessment of the decrease in solute concentrations in reclaimed water when combined with natural precipitation for groundwater recharge. In this case, it is shown that concentrations of TDS, TOC, and total nitrogen in reclaimed water are decreased substantially by factors ranging from about two to four prior to being further diluted by groundwater in the subsurface and decreased by the other processes described above. In this manner, a proper perspective can be developed for the relative environmental impact of the use of reclaimed water for snowmaking.

For dryer-than-average years, snowmaking would be intensified and atmospheric water losses would be higher, and these conditions would have the effect of increasing solutes in the water infiltrating as recharge. Concurrently, the drier conditions would limit the volume of water available for recharge. In the case of very dry conditions, such as is assumed herein for the range of climatic conditions, precipitation would be very limited and the percolation of groundwater in the unsaturated zone downward to the perched aquifers would be impeded. In very dry climatic conditions, the mobility of dissolved solutes in the unsaturated zone would be effectively slowed until wetter climatic conditions and greater flux of infiltrated water subsequently could remobilize the accumulated solutes. In wetter-than-average conditions, the converse would be true. Increased precipitation and associated groundwater recharge would substantially decrease solute concentrations in the unsaturated zone and eventually in the perched groundwater zones. The net effect of changes in groundwater recharge from alternating dry, average, and wet climatic conditions would be to dilute and attenuate the flux of solute concentrations reaching the underlying perched aquifer system.

Agassiz Sub-watershed

Table 3H-2 provides projected solute concentrations in groundwater recharge in the Agassiz sub-watershed. Inspection of this table indicates that the TDS, TOC, and total nitrogen concentrations are projected to be about 24 mg/L, 0.4 mg/L, and 1.7 mg/L, respectively, in average-year precipitation conditions. Although these concentrations are larger than comparable concentrations assumed for water available for groundwater recharge from natural precipitation, the concentrations of TDS and TOC are decreased by more than an order of magnitude from concentrations in the reclaimed water.

Hart Prairie Watershed

Tables 3H-2 and 3H-3 provide the projected solute concentrations in the water available for groundwater recharge in the Snowbowl sub-area and Hart Prairie watershed. As demonstrated by the projected groundwater recharge, the combined area that comprises the Hart Prairie watershed contributes more natural precipitation to recharge and consequently reduces the projected solute concentrations. The groundwater from this combined area is calculated to have a bulk concentration of about 33 mg/L TDS, 0.6 mg/L TOC and 1.6 mg/L total nitrogen, assuming groundwater recharge from the Snowbowl sub-area blends with recharge in the surrounding Hart Prairie watershed. The projected values illustrate that resulting concentrations of TDS and TOC are more than an order of magnitude smaller than those in the reclaimed water. The projected total nitrogen concentration is not decreased to the same degree due to the input of total dissolved nitrogen compounds present in natural precipitation.

Due to the distant location of the four small springs downgradient from the Agassiz sub-watershed (Figures 3H-1 and 3H-3) and limited overall change in solute concentrations (Table 3H-2), the anticipated indirect effects to water quality at these springs from Alternative 2 are considered to be negligible.

Alternative 3

The facilities improvements proposed in Alternative 3 have a less significant effect on projected water quality impacts to groundwater recharge. Projected water quality resulting from Alternative 3 is very similar to that projected for existing conditions discussed with Alternative 1.

CUMULATIVE EFFECTS

Scope of Analysis

Temporal Bounds

The temporal bounds of the cumulative effects analysis for watershed resources extends from the initial development of the Snowbowl in 1938 into the foreseeable future for which this and other projects can be expected to continue within and surrounding the Snowbowl SUP area.

Spatial Bounds

The physical extent of this cumulative effects analysis comprises the three primary watersheds depicted on Figure 3H-1 (the Hart Prairie watershed, Agassiz sub-watershed, and Snowbowl sub-area) as well as portions of the surrounding Kachina Peaks Wilderness area.

Past, Present, and Reasonably Foreseeable Future Actions

Past, present, and reasonably foreseeable activities having potential to cumulatively affect watershed resources include:

1. San Francisco Mountain Mineral Withdrawal
2. Bebbs Willow Restoration Project
3. Transwestern Lateral Pipeline Project
4. Inner Basin Water Pipeline Maintenance
5. Private Land Development
6. Miscellaneous Recreational Uses
7. Inner Basin Well Field
8. Use of City of Flagstaff Reclaimed Water
9. City of Flagstaff Water Well Fields

Appendix C includes the full list of past, present and reasonably foreseeable future actions analyzed in this document, as well as background information on each of them.

Alternative 1 - No Action

None of the identified past, present or reasonably foreseeable activities would combine with the effects anticipated under the No Action Alternative to create any significant cumulative watershed resource effects. (Refer to Proposed Action discussion.)

Alternative 2 – The Proposed Action

As indicated below, none of the identified past, present or reasonably foreseeable activities would combine with the effects anticipated under the Proposed Action to create any significant cumulative watershed resource effects.

San Francisco Mountain Mineral Withdrawal

The Peaks and surrounding area was withdrawn from availability for mineral entry in 2000. This action precludes individuals and entities from staking a mineral claim in preface to planned extraction activities within the withdrawn area. This action has and will provide added protection for soil and watershed resources by limiting potential ground disturbing activities associated with mining.

Bebbs Willow Restoration Project

Activities have been undertaken by The Nature Conservancy, Northern Arizona University, and the Forest Service to improve ecosystem conditions of the Bebbs willow-wet meadow community located in Hart Prairie through prescribed burning and tree thinning. The objective of the restoration project is to improve the hydrologic function in the 170-acre Fern Mountain Botanical Area by increasing groundwater availability in the shallow perched aquifer and springs which support the riparian habitat. The impacts from the prescribed burning and tree thinning are not considered to be long-term or significant with respect to cumulative watershed impacts when analyzed cumulatively with the alternatives addressed within this EIS. As noted in the analysis of indirect effects, watershed impacts from the proposed snowmaking for the Snowbowl may include an *increase* in the rate and/or duration of discharge from the springs in Hart Prairie that supply water for the Bebbs willow community. The additional discharge, to the extent it occurs, would be expected to enhance conditions for seed germination in the Bebbs willow community.

Transwestern Lateral Pipeline Project

This project is not within the spatial or temporal bounds of this cumulative effects analysis related to potential watershed effects; therefore, there are no cumulative effects to watershed resources associated with this project.

Inner Basin Water Pipeline Maintenance

This project is not within the spatial or temporal bounds of this cumulative effects analysis related to potential watershed effects; therefore, there are no cumulative effects to watershed resources associated with this project.

Private Land Development

Private land development within the watershed of the proposed Snowbowl improvements may lead to localized water resource impacts. The primary concern is associated with septic system discharges from the Snowbowl combined with those from a number of scattered private residences in lower Hart Prairie. Septic waste disposal has potential to cause local groundwater bacterial contamination, particularly where shallow groundwater may interfere with proper leach field function. In areas that are more developed, such as Fort Valley, there have been occasional, but significant, impacts of enteric bacteria and other septic wastes to shallow wells.[284] Due to the low-density development in the Hart Prairie area, the overall concern for fecal contamination in the watershed is generally low. Private land development in the Hart Prairie watershed is presently limited and likely to remain low density due to Coconino County zoning restrictions and availability of land and water supplies. Additionally, because these homes do not have power or winter road access, they are primarily used during the summer months when wastewater discharges from the Snowbowl are at their lowest levels. Therefore, the overall effect of potential water quality degradation from area-wide septic systems is expected to be negligible. The affects of septic waste disposal may, however, result in localized impacts within the sub-watersheds.

Other land development concerns include land disturbance from road and home-building, waste products from domestic livestock, and groundwater withdrawal from private wells. Due to the low-density of existing and planned private land developments within the analysis area, impacts from such development are considered to be inconsequential with respect the cumulative watershed impacts.

Miscellaneous Recreational Uses

Recreational use in the Hart Prairie area is moderate and will probably increase in the future. Individuals and groups use the area for recreational activities including hiking, camping, horseback riding, bicycling, and cross-country skiing. The recreational land use may cause loss of vegetative ground cover, soil compaction, and biological pollution leading to possible watershed effects. Generally, such disturbances are dispersed, localized, and insignificant with respect to their contribution to cumulative watershed impacts. Additionally, the Forest Service has developed best management practices to mitigate current and future recreational land uses.

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[284] Arizona Department of Environmental Quality, 1997.

Inner Basin Well Field

The Inner Basin well field for the City of Flagstaff lies outside the proposed areas of snowmaking and associated snowmelt runoff from the proposed Snowbowl operations. Due to the spatial separation of these two areas, both in distance and hydrogeologic features, activities at the Snowbowl can not impact the perched aquifers that supply groundwater within the Inner Basin to city wells.

Use of City of Flagstaff Reclaimed Water

Reclaimed water diverted to the Snowbowl would not be available for other reuse, such as irrigation of turf, dust suppression, etc., within the City of Flagstaff. However, City of Flagstaff Utilities Department records indicate there are only limited demands for reclaimed water during the winter months when the proposed diversion to the Snowbowl would occur. For instance, the Rio de Flag WRF produces, on average, approximately 1.9 million gallons of reclaimed water per day but diverts only around 55,000 gallons of reclaimed water per day for reuse during the period of November through February. Due to limited irrigation demands in the winter months, reuse is not projected to be significant in the future. Therefore, no significant cumulative effects were identified for Snowbowl diversion of reclaimed water on water reuse in Flagstaff.

City of Flagstaff Water Well Fields

Public comments submitted as apportion of this analysis process indicated concerns regarding the consumptive use of reclaimed water for snowmaking and the potential impact on recharge to the regional C-aquifer in Flagstaff. The primary concern expressed within the public comments is that the use of reclaimed water for snowmaking would reduce winter discharges of treated wastewater to the effluent-dependent waters of the Rio de Flag, which directly recharges the regional C-aquifer. The comments note that water reuse for snowmaking would result in substantially larger losses due to sublimation and evaporation at the Snowbowl and, therefore, substantially less water would be available for recharge to the regional aquifer.

As previously discussed, the right to the use of reclaimed water in Arizona was established by the 1989 decision of the Arizona Supreme Court in the case of *Arizona Public Service v. Long*.[285] In this case, the Arizona Supreme Court determined that effluent is neither surface water nor groundwater and cities can put the reclaimed water to any reasonable use they see fit, within existing legislative restrictions. Based upon this decision, the authority of the city to provide reclaimed water to the Snowbowl is not subject to decision by the Forest Service and is therefore not within the jurisdictional purview of this analysis.

Although this issue extends well beyond the scope of this EIS, data generated during the preparation of this analysis provides a quantitative basis to assess these public comments. The following discussion is provided as general information but will not be specifically considered in selecting an alternative.

[285] McGinnis, 1990

The potential changes in recharge to the regional aquifer, assuming effluent discharged to the Rio de Flag provided such recharge in a time frame discernible in human terms, are summarized in Table 3H-4.

Table 3H-4
Comparative Groundwater Recharge Estimates
Analysis of Four-Month Projected Recharge to the Regional Aquifer
As based on Average Year Precipitation

	Existing Conditions (AF)	Proposed Action (AF)	Change in Recharge (AF)
Treated effluent released to the Rio de Flag[a]	632	268	
Evapotranspiration loss from Rio de Flag[b]	10	4	
Projected recharge from Rio de Flag	622	264	-358
Reclaimed water use for snowmaking[c]	0	364	
Projected groundwater recharge from snowmaking[d]	0	180	180
Net Change In Recharge			*-178*

[a] Amount of treated effluent released to the Rio de Flag is based on 2002 monthly discharges for the four-month period from November through February reported by the City of Flagstaff Utilities Department.
[b] Estimated evapotranspiration losses are extrapolated from calculations for evapotranspiration in the water budget prepared by Schwartzman and Springer (2002).
[c] Estimates for reclaimed water requirements for snowmaking are provided for average-year precipitation conditions by Sno.matic Controls and Engineering, Inc. (2003).
[d] Estimates of groundwater recharge are derived from modeling results (Resource Engineering, Inc., 2003) for average-year precipitation in the combined Snowbowl sub-area and Agassiz sub-watershed.

Based on data developed in this study and as noted in Table 3H-4, proposed snowmaking would result in an estimated net average reduction in groundwater recharge to the regional aquifer of 178 AF per year. This calculated reduction represents slightly more than two percent of the City of Flagstaff's total annual water production (as averaged over the 10 year period from 1992 to 2001). This amount is negligible (less than 0.061 percent) compared to the annual groundwater recharge rate of approximately 290,000 AF to the regional aquifer estimated for the Lake Mary well field.[286] The cumulative impact from Snowbowl diversion of treated effluent on the water available for recharge in the Rio de Flag drainage in the Flagstaff city limits is considered to be negligible. Therefore, there are no cumulative watershed impacts identified for this issue in relation to the alternatives analyzed within this analysis.

Alternative 3

None of the identified past, present or reasonably foreseeable activities would combine with the effects anticipated under Alternative 3 to create any significant cumulative watershed resource effects.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

No irreversible or irretrievable effects or commitments to watershed resources are anticipated as a result of implementation any of the alternatives.

[286] Bills and others, 2000

3I. SOILS AND GEOLOGY

SCOPE OF THE ANALYSIS

The proposed application of machine-produced snow may have the effect of increasing total water availability, potentially leading to an increase in the duration, intensity, and/or quantity of total annual snowmelt. Therefore, this analysis of soils and geology was limited to existing and proposed areas of disturbance within the Snowbowl SUP area, as well as terrain proposed to receive snowmaking coverage. Eight sub-watersheds in the vicinity of the SUP area having potential to change under the Proposed Action were analyzed in order to make an assessment of current and projected annual water balance for use in addressing the indicators in the Environmental Consequences section.

EXISTING CONDITIONS

CLIMATE

The climate of the San Francisco Peaks, similar to other areas in the state of Arizona, is characterized by a cyclic regime of winter precipitation, spring drought, summer precipitation, and fall drought.[287] Precipitation typically arrives from the northwest in the winter, while its origin is from the southeast in the summer. Winter precipitation, frequently snow at higher elevations, is associated with frontal storms moving into the region from the Pacific Northwest. Surface heating in the winter is less pronounced than in the summer, thus wintertime upslope air movement is comparatively slow. Wintertime cloud cover is common, and precipitation is frequently widespread and relatively low in intensity, promoting infiltration and groundwater re-charge.

The primary source of moisture for summer rains is the Gulf of Mexico. This moisture moves into the highlands from the southeast, passes over highly heated and mountainous terrain, rises rapidly, cools, and condenses. Summer storms, primarily convectional, are often intense and local rather than widespread. As a result, summer precipitation creates much less groundwater recharge when compared to the winter season. Summer rains typically begin in early July, breaking the prolonged spring drought and provides relief from the hot weather of June and July.

Winter precipitation is more variable than summer rainfall in amount and time of occurrence from year-to-year. However, yearly variations in precipitation generally decrease with increases in elevation. Winter precipitation is generally responsible for the majority of the annual recharge produced in the region. Spring drought is often more detrimental to most plants and animals in the region than the fall drought, due to the higher temperatures and wind conditions during the beginning of the growing season. Several weather stations are located near the Snowbowl, but no single station adequately characterizes the Snowbowl's climatic regime. In order to arrive at a site-specific set of climate variables for the purposes of modeling the annual water balance at Snowbowl, several sources were examined. Spatially-distributed precipitation estimates from the

[287] Beschta et al., 1974; Campbell et al., 1982

Parameter-elevation Regressions on Independent Slopes Model (PRISM) [288] were utilized to characterize the average-year monthly distribution of precipitation for the project area. PRISM is a system that uses point data and a digital elevation model (DEM) to generate gridded estimates of climate parameters. PRISM is well-suited to mountainous regions, because the effects of terrain on climate play a central role in the model's conceptual framework. PRISM provides a robust methodology for inference of the average-year monthly climate distribution. Dry and wet year climate parameters were inferred from the average-year PRISM using modifiers computed from nearby regional SNOTEL sites. The results of this precipitation analysis procedure are summarized as an average among all delineated sub-watersheds for the Snowbowl SUP area as a whole and are presented in Table 3I-1.

Table 3I-1
Monthly Precipitation
Arizona Snowbowl Project Area

	Precipitation (Inches)		
Month	**Average Year**	**Dry Year**	**Wet Year**
January	2.7	0.6	7.2
February	2.7	0.4	5.1
March	3.4	1.1	5.2
April	2.0	0.4	2.0
May	1.0	0.2	0.7
June	0.7	0.3	0.4
July	4.0	2.1	2.4
August	4.0	1.4	4.5
September	2.4	2.3	5.2
October	1.9	0.9	1.7
November	2.5	0.8	3.0
December	2.8	1.9	8.4
Total	***30.0***	***12.4***	***45.7***

Source: Resource Engineering, Inc., 2003

For temperature, proximal SNOTEL stations provide long-term high-elevation records, although the nearest sites, including Fry, Mormon Mountain, and White Horse Lake, are all at lower elevations. In order to derive temperature data, records from Fry, the SNOTEL site closest to the Snowbowl, were selected and elevation-adjusted via the dry adiabatic lapse rate. Inferred monthly mean, maximum, and minimum temperature trends for the Arizona Snowbowl vicinity are portrayed in Table 3I-2.

[288] Daly et al., 1994

Table 3I-2
Monthly Temperatures
Arizona Snowbowl Project Area

Month	Air Temperature (°F)		
	Average	Max	Min
January	13.6	31.8	1.2
February	15.7	34.1	3.1
March	20.3	39.2	6.1
April	26.9	46.1	11.2
May	34.2	54.9	15.9
June	40.9	65.0	20.7
July	45.1	73.0	29.2
August	44.7	72.1	29.3
September	39.4	67.6	22.8
October	28.2	55.4	13.5
November	19.1	38.4	6.1
December	13.3	31.3	1.5

Source: Resource Engineering, Inc., 2003

WATER BALANCE

The primary watersheds within the Snowbowl SUP area were derived from available digital elevation data. The spatial extent and acres of existing ski trails within each of these watersheds is outlined in Table 3I-3. The table shows only watersheds that would experience changes under the proposal.

Table 3I-3
Sub-Watershed Characteristics

Watershed	Watershed Area (acres)	Acres of Developed Trails
Hart Prairie	820.2	17.5
Humphreys	284.1	21.1
Lower Agassiz Ridge	232.2	5.5
Middle Agassiz Ridge	229.1	2.8
Snowbowl	648.5	86.3
Sunset	79.6	5.3
Upper Agassiz Ridge	263.2	0.3
Total	***5,692.3***	***138.8***

Source: Resource Engineering, Inc., 2003

The location and extent of these primary watersheds are indicated in Figure 3I-1.

Figure 3I-1: Delineated Watersheds

There are no continuous records available to assess the annual water balance within these small tributary watersheds. Therefore, water balance scenarios for existing conditions for average, dry, and wet years were developed using water balance techniques and snowmelt modeling as outlined in detail in two publications: An Approach to Water Resources Evaluation of Non-Point Silvicultural Sources (WRENSS)[289] and the Water Management Research Project Handbook.[290] Within the infiltrative andesols[291] predominant on the slopes of the San Francisco Peaks, little to no net surface runoff is produced from the basins. Thus, the water balance may be characterized by precipitative input, atmospheric and watershed losses, and re-charge to soil and groundwater.

The present water balance for these watersheds is affected by the existing terrain network. Various land management actions can, intentionally or unintentionally, affect the water balance. For example, numerous studies have demonstrated that timber harvest or eradication, as by wildfire, tends to increase water yield and streamflow.[292] The creation of openings for ski trails involves timber harvest and, as a result, decreases the amount of water loss to the atmosphere. This can potentially increase the amount of water available for routing through the watershed, via either surface runoff or infiltration. The mechanisms for this include: 1) decreasing the amount of evapotranspiration (use of water by plants) through timber removal; 2) decreasing snow loss associated with interception (the trapping of snow in the forest canopy until it is sublimated or evaporated to the atmosphere); 3) accelerating runoff (more rapidly removing water from the forest thereby reducing the amount available on-site for plant use); and 4) increasing deposition in openings (reducing airborne snow particle ablation[293] and loss). In addition, in the case of groomed ski trails, it is theorized that snow grooming may affect water yield through modifications in snowpack density by grooming equipment and skiers.

Assessing the existing water balance requires an estimation of the amount of excess water available from forested and open areas under pre-developed conditions, and a subsequent determination of the relative change produced by the trail system and snowmaking.

To accomplish this, a water balance is computed that determines the amounts of precipitation and evapotranspiration associated with each contributing area, the remainder being water potentially available for recharge. A computer model, called the Subalpine Water Balance Simulation Model,[294] has been developed by the Forest Service to create such a balance.

In concept, the model takes seasonal precipitation applied to a locale that is defined in terms of vegetation, by type and density, and aspect and then subtracts the evapotranspirational demands of the vegetation to compute the amount of water potentially available for runoff or re-charge. To reflect changes in vegetation due to

[289] Troendle, C.A., and Leaf, C.F., 1980
[290] Leaf, C. F., 1986, Colorado Ski Country USA, 1986
[291] Soils formed mainly in volcanic ash or cinders, exhibiting andic soil properties.
[292] Troendle, C.A. et al., 2001b; Wilm H.G. and E.G., Dunford, 1948; Satturland, D.R. and H.F. Haupt, 1967; Hoover, M.D., 1971; Gary, H.L., 1974; Troendle, C.A., 1979; Schmidt, R.A., 1991; Birkeland, K.W., 1996
[293] Ablation is the mechanical destruction of snow and ice particles.
[294] Leaf and Brink, 1973a and b

timber removal, the model modifies evapotranspirational demands to reflect altered vegetation density, defined as basal area or cover density.

The Subalpine Water Balance Model was used to develop a procedure and a set of nomographs[295] to aid analysts in making non-point source pollution assessments. That procedure formed WRENSS. The numerous detailed data inputs required by the model were reduced in the WRENSS procedure by making a large number of model runs and using the results to develop the above-mentioned nomographs. This simplification and the use of evapotranspiration modifier coefficients facilitate the analysis while not significantly diminishing the value of the output.

The water balance of the WRENSS model is coupled with a snowmaking hydrology computation process developed as a result of a 1986 study, commissioned by Colorado Ski Country USA. This study assessed water consumption attributable to snowmaking uses. The study found that initial losses, those essentially occurring at the snowmaking gun, are a function of relative humidity and temperature at the time of snowmaking, and average approximately six percent.[296] Additional watershed losses include sublimation, evaporation, and evapotranspiration, and occur as a function of aspect, elevation, and vegetation. The sublimation loss component is of particular interest in the micro-climate of the San Francisco Peaks. The wintertime climate within the San Francisco Peaks frequently exhibits periods of dry weather with persistent sunshine, interspersed with periodic snowstorms. Meanwhile, high winds frequently occur on the Peaks due to their high elevation in relationship to the predominant elevation of the surrounding terrain. These factors can contribute to substantial snowpack loss via atmospheric sublimation.[297]

Sublimation

Avery et al. conducted a sublimation measurement experiment over the 1990/91 and 1991/92 winter seasons at two sites in Flagstaff, one located on the NAU campus, and a second located at Pulliam Airport.[298] Two sublimation-measurement devices were emplaced at each site: one shielded from open sky conditions; and another exposed to ambient sky conditions. The 1990/91 season exhibited an unusually dry mid-winter period, with the result that the sublimation metering devices were dry, and no data was logged from mid-January through early March. The 1991/92 winter season exhibited above average precipitation due to the influence of El Nino conditions, and provided a more continuous record of sublimation measurements, with only a brief gap in data during early February. Over the course of the experiment the mean daily observed evapo-sublimation loss was 0.06 inch of water equivalent per day, averaged over days with no precipitation. The maximum rate was observed to be 0.31 inch of water equivalent per day, and was observed during dry, clear, and windy conditions.

Sublimation rates are highly spatially variable, and are dependent on temperature, wind speed, solar radiation, and humidity. However, in order to facilitate a reasonable analysis

[295] A graph consisting of curves graduated for a number of variables, establishing a relationship between multiple related values.
[296] Leaf, C.F., 1986
[297] Higgins, 1998
[298] Avery et al., 1993

of the effects of snowmaking on the water balance of the project area, an estimate of the amount of snow water equivalent lost from sublimation from the snowpack is required. The results of the 1993 Avery et al. study provide sublimation observations over the course of two seasons of observation, offering the most temporally extensive dataset available. Therefore, for the average- and wet-year scenarios, Avery et al.'s mean daily rate of 0.06 inch of water equivalent sublimation loss per day was applied to the machine-produced snowpack throughout the course of the snowmaking season. As a conservative assumption, this loss rate was applied uniformly, without consideration for days with cloudy sky conditions or precipitation, during which lower or zero sublimation rates could be realized. For dry-year scenarios, the maximum observed loss rate of 0.31 inch of water equivalent per day, observed during the 1993 Avery et al. study, was applied following the same methodology.

The nomographs and evapotranspiration modifier coefficients of the WRENSS model are grouped into eight regional categories within the continental United States. The Snowbowl project area is situated within region (4): Rocky Mountain/Inland Intermountain Region (snow dominated precipitation regimes). This particular WRENSS region covers a large spatial extent, ranging from Arizona and New Mexico at its southern extreme, to Montana and Southern Idaho at its northern extreme. The WRENSS groupings reflect the experimental watershed data used to derive and calibrate the regional coefficients appropriate to that category. Experimental data from the Forest Service Beaver Creek and Thomas Creek experimental watersheds within Arizona were included in the population of data used in the original WRENSS analyses; however, the preponderance of available experimental data within region (4) was derived from watersheds situated in more northern climates.[299]

Because of the unique wintertime climate of the Arizona mountain regions, in which warm temperatures can influence losses from the snowpack during winter months, the region (4) evapotranspiration nomographs were examined in comparison to data from the Beaver Creek experimental watershed, in order to evaluate the potential need for site-specific adjustments to the regional WRENSS nomographs.

The Beaver Creek Experimental Watershed is located between latitudes 34° 30' and 35° north, and 111° 30' to 112° west longitude in north-central Arizona.[300] The watershed's center is about 50 miles south of Flagstaff, Arizona, in Coconino and Yavapai counties. Established in 1956 by the Forest Service as a center for watershed management research within the pinion-juniper and ponderosa pine vegetation types, the site encompasses 275,000 acres on the Coconino National Forest.

Nineteen years of precipitation and runoff data (1962-1981) were obtained for sub-watershed 20 within the Beaver Creek watershed. This watershed is at the highest elevation zone within the Beaver Creek drainage, and is dominated by ponderosa pine forest. Over the course of the Beaver Creek program, sub-watershed 20 was utilized as a hydrologic reference or control watershed, wherein no experimental changes in treatment or management were applied. Comparison of the WRENSS model water balance utilizing the default regional evapotranspiration-precipitation nomographs, versus

[299] Leaf, C.F., 2003

[300] USDA Forest Service, 2001

observed average behavior for sub-watershed 20 provided a basis to adjust the model to more closely match site-specific conditions at Snowbowl. The WRENSS seasonal evapotranspiration nomographs were adjusted upwards by 17 percent, on average, to provide closer agreement with the observed water-balance data from Beaver Creek sub-watershed 20.

The water balance computed via the WRENSS model, modified to reflect the contributions of snowmaking water computed via the above procedures, together provide estimates for water yield typical of sub-alpine mountain watersheds. Tables 3I-4 through 3I-6 portray the water balance characteristics for watersheds within the project area for average, dry, and wet-year conditions. Only those watersheds slated for snowmaking or terrain modification under the Proposed Action are shown.

Table 3I-4
Average Year Water Balance

Watershed	Area (acres)	Precipitation (AF)	Watershed Loss (AF)	Recharge (AF)	Percent Loss
Hart Prairie	820.2	1930.1	1236.9	693.1	64%
Humphreys	284.1	784.0	429.0	355.0	55%
Lower Agassiz Ridge	232.2	568.1	368.3	199.8	65%
Middle Agassiz Ridge	229.1	573.5	373.7	199.8	65%
Snowbowl	648.5	1791.3	940.8	850.5	53%
Sunset	79.6	192.7	111.6	81.1	58%
Upper Agassiz Ridge	263.2	672.4	432.8	239.7	64%
Total	***2,556.9***	***6,512.1***	***3,893.1***	***2,619.0***	***61%***

Source: Resource Engineering, Inc., 2003

Table 3I-5
Dry Year Water Balance

Watershed	Area (acres)	Precipitation (AF)	Watershed Loss (AF)	Recharge (AF)	Percent Loss
Hart Prairie	820.2	794.3	776.7	25.9	98%
Humphreys	284.1	322.6	295.6	27.0	92%
Lower Agassiz Ridge	232.2	233.8	233.8	0.0	100%
Middle Agassiz Ridge	229.1	236.0	236.0	0.0	100%
Snowbowl	648.5	737.2	637.6	99.5	86%
Sunset	79.6	79.3	74.8	4.5	94%
Upper Agassiz Ridge	263.2	276.7	276.7	0.0	100%
Total	***2,556.9***	***2,679.9***	***2,531.2***	***156.9***	***96%***

Source: Resource Engineering, Inc., 2003

Table 3I-6
Wet Year Water Balance

Watershed	Area (acres)	Precipitation (AF)	Watershed Loss (AF)	Recharge (AF)	Percent Loss
Hart Prairie	820.2	2941.8	1296.3	1645.4	44%
Humphreys	284.1	1194.9	443.4	751.5	37%
Lower Agassiz Ridge	232.2	865.9	383.6	482.3	44%
Middle Agassiz Ridge	229.1	874.1	386.0	488.0	44%
Snowbowl	648.5	2730.2	976.2	1754.0	36%
Sunset	79.6	293.8	117.4	176.3	40%
Upper Agassiz Ridge	263.2	1024.9	445.7	579.1	43%
Total	***2,556.9***	***9,925.6***	***4,048.6***	***5,876.6***	***41%***

Source: Resource Engineering, Inc., 2003

Area-normalized results, averaged over all watersheds, are portrayed in Table 3I-7.

Table 3I-7
Area-Normalized Water Balance

Climate	Precipitation (in)	Watershed Loss (in)	Recharge (in)	Percent Loss
Average	31.6	18.3	13.3	58%
Dry	13.0	12.1	0.9	93%
Wet	48.2	19.0	29.3	39%

Source: Resource Engineering, Inc., 2003

The results of the water balance modeling are generally consistent with expected trends for semi-arid forested environments, where evapotranspiration rates are limited by soil moisture availability. In these conditions, dry conditions prevail during much of the growing season, and soil moisture deficits can become substantial. Prior studies of evapotranspiration rates from climatically and vegetatively similar ponderosa pine forests in northern New Mexico over a four-year period extending from 1993 through 1996 yielded an average annual evapotranspiration loss of 18.0 inches, which agrees well with the prediction of the water balance model.[301] The high percentage losses in dry years are related to high atmospheric moisture demand driven by lower relative humidities, paired with higher temperatures. Lower percentage losses in wet years are derived from lower atmospheric demand, paired with increased moisture content in soils and shallow groundwater, leading to greater re-charge fractions.

GEOLOGY

The San Francisco Volcanic Field covers approximately 1,800 square miles in northern Arizona. The Field lies along the southern perimeter of the Colorado Plateau, defined by the Mogollon Rim to the south of Flagstaff. The most prominent peaks within the field are the San Francisco Peaks, including Humphreys Peak, which at 12,633 feet is the highest mountain in Arizona. Collectively, Humphreys Peak, Agassiz Peak (12,345 feet), and Fremont Peak (11,696 feet) are referred to as the San Francisco Peaks. A large portion of the San Francisco Volcanic Field lies within the Coconino and Kaibab national

[301] Brandes, David and B. Wilcox, 2000

forests. This zone of relatively recent volcanism contains more than 600 volcanoes, active at various time periods during the past six million years.[302]

Most of the mountains between Flagstaff and the Grand Canyon are dormant volcanoes, and are comparatively young geologically. Most prominent among these features are basaltic cinder cones such as Sunset Crater, O'Leary Peak, Bill Williams Mountain, and Kendrick Peak. Sunset Crater is the youngest volcano within the field, last erupting less than 1,000 years ago. The oldest volcanic features within the San Francisco field are a series of six million year old basaltic lava flows that extend south and southwest from the San Francisco Peaks vicinity.[303] These basalts overlie the Triassic sand and mudstones of the Moenkopi formation, as well as the horizontally extensive Permian Kaibab limestone.[304] The younger andesites, rhyolites, and dacites of the San Francisco Peaks exist on top of these older basaltic flows.

San Francisco Peaks are a stratovolcano, with moderately steep slopes formed by the gradual accumulation of layers of andesitic lava flows, cinders, and ash, inter-lensed with deposits from volcanic mudflows. The San Francisco Peaks are the only stratovolcano within the San Francisco Volcanic Field. The eruptions that formed the Peaks occurred between 0.4 and one million years ago.[305] The Inner Basin is a prominent glaciated valley along the northeastern slopes of the San Francisco Peaks. Most geologists currently believe that the Inner Basin is a caldera formed by a lateral blast similar to that which occurred at Mt. St. Helens in 1980.[306] Projecting the existing slope of the San Francisco Peaks range upward, it is estimated that the original summit of the San Francisco Peaks reached approximately 15,400 feet[307] Pleistocene era glaciation further sculpted the Inner Basin, and occurred after the most recent period of volcanic orogenic activity.[308]

SOILS

Information on soils within the project area was obtained from the CNF Terrestrial Ecosystem Survey GIS database. Within the CNF Terrestrial Ecosystem Survey database, soils are classified to the family level of Soil Taxonomy. Soils exhibiting very similar profiles comprise a soils family. Allowing for differences in surface texture or underlying layers, soils within a family exhibit major horizons that are similar in thickness, composition, and arrangement. A number of soils families are present throughout the project area; the predominant mapped soils units within the project area are outlined in Table 3I-8 and their locations are graphically depicted in Figure 3I-2.

[302] Priest et al., 2001
[303] Higgins, 1998
[304] Id.
[305] Priest et al., 2001
[306] Id.
[307] Higgins, 1998
[308] Id.

Table 3I-8
Mapped Soil Units
Arizona Snowbowl SUP Area

Map Unit	Component[a]	Component Name	Acres	Percent of Mapped Soils
640	0.1	Pachic Udic Argiborolls	62.1	8%
	0.5	Pachic Udic Haploborolls		
	0.5	Pachic Paleborolls		
715	0.1	Andic Cryoborolls	64.1	8%
	0.5	Pachic Cryoborolls		
740	0.1	Cryic Pachic Paleborolls	271.8	35%
	0.2	Andic Cryoborolls		
	0.5	Pachic Cryoborolls		
770	0.1	Vitrandic Cryochrepts	167.1	21%
	0.2	Talus		
	0.5	Mollic Cryoboralfs		
785	0.1	Andic Cryoborolls	133.0	17%
	0.5	Pachic Cryoborolls		
	0.6	Vitandic Cryochrepts		
790	0.1	Vitrandic Cryochrepts	52.2	7%
	0.5	Vitrandic Cryoborolls		
	0.6	Rock Outcrop		
850	0.1	Pergelic Cryochrepts	27.4	4%
	0.5	Talus		
	0.6	Pergelic Cryorthents		

[a] Components within a soils map unit are identified by a decimal and followed by a number (.l to .4). A maximum of four major named components are allowed in each map unit. Each map unit can have two minor inclusion components (.5 and .6).
Source: USDA Forest Service, 2003

Figure 3I-2: Project Area Soils Mapping

Soils unit 640 is a gravelly loam, dominated by components of Pachic Udic Argiborolls, with inclusions of Haploborolls and Paleborolls, realized as alluvium/colluvium from andesite/dacite parent material. This map unit is classified as a fire disclimax.[309] Fire created and maintained the open park-like conditions of this unit's predominant grasslands prairies in the past. Slopes range from zero to 40 percent. This unit occurs on warmer, dryer aspects than the adjacent mixed conifer map units. This map unit is dependent on recurrent wildfire to maintain the high canopy coverage of grass and low canopy coverage of mixed conifer.

Soils unit 715 is a bouldery sandy loam, dominated by an Andic Cryoborolls component, with Pachic inclusions. The unit is deposited as colluvium from andesite/dacite parent material. Vegetation within this unit is currently in mid to late seral stage as indicated by the high canopy cover. Exposures of andesite rock outcrop occur throughout the map unit. Slopes range from 25-35 percent.

Soils unit 740 is a gravelly fine sandy loam. The primary soils classification is Cryic Pachic Paleborollos with major inclusions of Andic Cryoborolls and minor inclusions of Pachic Cryoborolls. The soils are formed as colluvium of andesite/dacite parent material, and andesite rock outcrop may occur in the upper end of the slope range. This component has a severe erosion hazard. Natural re-generation potential is high.

Soils unit 770 is a stony fine sandy loam. The primary taxonomic classification is Vitrandic Cryochrepts, with Talus outcrops and Mollic Cryoboralfs inclusions. The soil is derived as colluvium and residuum from andesite/breccia parent material. This shallow to moderately deep soil occurs in the vicinity of rock outcrop and talus. Snow avalanche hazard is moderate in areas with little or no tree canopy cover. Mass wasting hazard is moderate and occurs as debris slide and debris avalanche in and around talus areas. This map unit has a moderate erosion hazard. Natural regeneration and reforestation potentials are low due to surface rock fragments and cold climatic conditions.

Soils unit 785 is a very stony fine sandy loam. The primary taxonomy is Andic Cryoborolls, with minor inclusions of Pachic Cryoborolls and Vitandic Cryochrepts. Most areas within this unit are currently in mid-seral vegetative stage, due to past wildfires. Snow avalanche hazard is moderate in areas with little or no tree canopy cover. This map unit has a severe erosion hazard. Natural re-generation potential is high. Reforestation and re-vegetation potentials are low due to very steep slopes.

Soils unit 790 is a very cobbly sandy loam, with a primary classification of Vitrandic Cryochrepts, with minor inclusions of Vitrandic Cryoborolls and rock outcrops. The soil is a colluvium derived from dacite/andesite parent material. This soil's mass wasting hazard is severe. Snow avalanche hazard is moderate in areas with little or no tree canopy cover. Erosion hazard is severe. Natural regeneration, reforestation and revegetation potentials are low due to steep slopes and cold climatic conditions.

[309] A relatively stable ecological community often including organisms foreign to the region and displacing the climax (the final stage in ecological succession) because of natural (fire, etc.) or anthropogenic disturbance.

Soils unit 850 is an extremely bouldery sandy loam, a colluvium derived from andesite/breccia parent material. The taxonomy is a Pergelic Cryochrepts, with Talus and Cryorthents inclusions. Shallow and moderately deep soils may occur in the vicinity of rock outcrop and talus. Mass wasting hazard is moderate and occurs as debris slide and debris avalanche around talus areas. Snow avalanche hazard is moderate to high. This high-elevation soil supports a fragile alpine tundra habitat. This map unit has a severe erosion hazard. Revegetation potential is low due to surface rock fragments and cold climatic conditions.

The primary use and management considerations for the soils units present in the SUP area are summarized in Table 3I-9.

Table 3I-9
Mapped Soils Units
Management and Usage Limitations

Map Unit	Component	Percent of Mapped Units	Cut and Fill Slope Stability	Unsurfaced Road Stability	Erosion Hazard	Re-vegetation Potential
640	0.1	8%	N/A	Moderate	Moderate	High
	0.5		*	*	*	*
	0.6		*	*	*	*
715	0.1	8%	Moderate	Moderate	Severe	Low
	0.5		*	*	*	*
740	0.1	35%	Moderate	Moderate	Severe	Moderate
	0.2		Moderate	Moderate	Severe	Low
	0.5		*	*	*	*
770	0.1	21%	Moderate	Moderate	Severe	Moderate
	0.2		Moderate	Moderate	Severe	Low
	0.5		*	*	*	*
785	0.1	17%	Severe	Severe	Severe	Low
	0.5		*	*	*	*
	0.6		*	*	*	*
790	0.1	7%	Severe	Severe	Severe	Low
	0.5		*	*	*	*
	0.6		*	*	*	*
850	0.1	4%	Severe	Severe	Severe	Low
	0.5		*	*	*	*
	0.6		*	*	*	*

* = No record.
Source: USDA Forest Service, 2003

Overall, the primary soils units within the SUP area exhibit low to moderate re-vegetation potential, and severe erosion hazards. Maintenance of vegetative cover is important to minimize the potential for sheet and rill erosion with these soil units.

ENVIRONMENTAL CONSEQUENCES

SUMMARY OF ENVIRONMENTAL CONSEQUENCES AND CONCLUSIONS

Major conclusions and determinations of this Soils and Geology analysis are summarized below. A more detailed analysis of the direct and indirect environmental consequences (from which this summary was derived) follows.

Alternative 1 - No Action

Under the No Action Alternative, the infrastructure and operation of the Snowbowl would remain unchanged from current conditions. The environmental consequences of the No Action alternative would reflect those associated with the on-going operation of the existing ski area, including potential disturbances to vegetative cover, and/or soils associated with routine maintenance and repair requirements, occurring in previously disturbed areas. No consequences to the watershed hydrology or soils chemistry would be realized under the No Action Alternative.

Alternative 2 – The Proposed Action

Anticipated changes in the duration and intensity of annual snowmelt

The Proposed Action's 205 acres of snowmaking would result in a 15 percent increase in recharge in the primary receiving watershed, with a six percent increase overall. These water balance effects alone would be unlikely to increase the risk for surface flow, rilling, or sedimentation on un-graded terrain, where high infiltration rates result in little or no surface runoff. On graded terrain, soils compaction can result in surface runoff generation. In areas where there are no topographic constraints (i.e., confined valleys) to concentrate surface flows, the potential for rilling and sedimentation may be adequately mitigated via careful implementation and maintenance of typical drainage management routing infrastructure (i.e., waterbars). In areas where the surface topography tends to concentrate surface flows, increased water inputs would result in a moderate to high risk of rilling or sedimentation, as evidenced by their occurrence in existing confined graded terrain on *Logjam* (trail #25).

Anticipated changes in erosion/sedimentation

The grading of terrain associated with the Proposed Action would result in a post-disturbance increase of 530 tons of net sediment detachment, which would decrease to 87 tons following six to 10 years of re-vegetation. This represents a substantial potential increase in sediment yield. Preservation of topsoil prior to grading, and re-distribution prior to re-seeding, would enhance re-vegetation potential, and mitigate the risk of increased detachment on slopes of gradients less than 30 percent. On steeper slopes of 30 percent gradient and higher, the rates of anticipated detachment coupled with low soil re-generation potential would make preservation of topsoil difficult. While mitigation measures such as jute-netting or geo-textile mesh can improve soils stability on steeper slopes, the risk of erosion and soil loss would be moderate to high.

Potential changes to soil chemistry due to anticipated increases in soil moisture consistency and nutrient loading

Input of reclaimed water from the City of Flagstaff's Rio de Flag Water Reclamation Facility in the form of snowmaking would alter the soils chemistry for affected soils units. Overall, percolating treated wastewater through the soil profile would be unlikely to have a negative impact on either the soils or treated water. Existing fecal coliform in the A-horizon soil could be reduced via the percolation of chlorinated wastewater. The acidity of the soil and parent material would be progressively buffered to more alkaline levels by percolation of the treated wastewater. The higher alkalinity would inhibit the leaching and mobilization of soils metals to the groundwater. The increased nitrogen loading via application of the reclaimed wastewater would be likely to initially cause increases in organic and bio-available nitrogen within the soils, until reaching a critical threshold. Subsequently, increases in nitrogen mineralization and inorganic nitrogen would be expected, followed by increased leaching of excess nitrogen through the soils column to groundwater.

Alternative 3

Anticipated changes in the duration and intensity of annual snowmelt

Because Alternative 3 would not implement snowmaking infrastructure with accompanying snowmaking water inputs, the water balance effects of this Alternative would be relatively minor. Trail clearing and grading activities would result in changes in the water balance. Interception and evaporation losses from the forest canopy would be reduced. Vegetation removal would affect the infiltration characteristics of the watershed, generally resulting in quicker runoff generation. Changes in vegetative cover would affect the solar energy balance of the watershed, permitting increased solar radiation and therefore earlier and faster snowmelt in areas where new trails would be implemented.

Anticipated changes in erosion/sedimentation

The grading of terrain associated with Alternative 3 would result in a post-disturbance increase of 369 tons of net sediment detachment, which would decrease to 73 tons following six to 10 years of revegetation. This represents a substantial potential increase in sediment yield. Preservation of topsoil prior to grading, and re-distribution prior to re-seeding, would enhance re-vegetation potential, and mitigate the risk of increased detachment on slopes of gradient below 30 percent. On steeper slopes of 30 percent gradient and higher, the rates of anticipated detachment coupled with low soil re-generation potential would make preservation of topsoil difficult. While mitigation measures such as jute-netting or geo-textile mesh can improve soils stability on steeper slopes, the risk of erosion and soil loss would moderate to high.

Potential changes to soil chemistry due to anticipated increases in soil moisture consistency and nutrient loading

The soils compaction and turnover associated with Alternative 3 grading and trail construction activities would cause compaction of soils and loss of organic matter and tilth,[310] and a decrease in soils aeration, within affected soils units. However, no snowmaking infrastructure would be implemented. Therefore, no changes to soils chemistry would occur due to the input of reclaimed water in the form of snowmaking.

DETAILED ANALYSIS OF DIRECT AND INDIRECT EFFECTS

Issue:

The Proposed Action has potential to change soil chemistry and moisture due to the application of machine-produced snow.

Indicator:

Anticipated Volume of Machine-Produced Snow Applied Under Various Scenarios: Dry Year, Average Year, and Wet Year

Alternative 1 – No Action

Under the No Action Alternative, implementation of snowmaking infrastructure would not occur, and current conditions as presented above would be expected to persist. No machine-produced snow would be applied within the project area.

Alternative 2 – The Proposed Action

Under the Proposed Action, a total of 205.2 acres of snowmaking terrain would be implemented at the Snowbowl. This terrain would be primarily implemented within the Snowbowl watershed, with smaller acreages implemented in other proximal watersheds (see Table 3I-3 Sub-Watershed Characteristics).

The depth of snow that would be initially produced on existing and proposed terrain would result in an average coverage depth across all terrain types of slightly more than 25 inches of snow. Estimated operational conditions under the varying climatic scenarios are outlined as follows:[311]

1. Once all the trails have been covered with the specified depth of snow, resurfacing operations would typically commence to recover from any thaws and replenish snow that has become hardened through wear and temperature cycling. The amount of resurfacing required would depend on natural snowfall. In a wet year, it is estimated that only the initial application would be required. This application could be spread out over the season if there was abundant snow early in the year, or it could be concentrated at the beginning of the season if the bulk of the snow arrives after December.

2. On an average year, it is estimated that an additional half-application of machine-produced snow would be required after the initial coverage for a seasonal total of 1.5 coverages.

[310] The state of aggregation of a soil especially in relation to its suitability for supporting growth of vegetation

[311] Sno.matic, 2003

3. On a dry year, it is estimated one additional full application of machine-produced snow would be required after the initial coverage for a seasonal total of two coverages.

Snowmaking water utilization under average, dry, and wet year conditions are outlined by watershed in Table 3I-10.

Table 3I-10
Anticipated Snowmaking Water Use

Watershed	New Snowmaking Acreage	Average Year Snowmaking Diversions (AF)	Dry Year Snowmaking Diversions (AF)	Wet Year Snowmaking Diversions (AF)
Hart Prairie	22.5	39.9	53.3	26.6
Humphreys	28.4	50.4	67.3	33.6
Leroux	0.0	0.0	0.0	0.0
Lower Agassiz Ridge	12.7	22.5	30.1	15.0
Middle Agassiz Ridge	3.9	6.9	9.2	4.6
Snowbowl	131.9	234.0	312.4	156.2
Sunset	5.5	9.8	13.0	6.5
Upper Agassiz Ridge	0.3	0.5	0.7	0.4
Total	***205.2***	***364.0***	***486.0***	***243.0***

Source: Resource Engineering, Inc., Sno.matic, 2003

Alternative 3

Under Alternative 3, implementation of snowmaking would not occur, and current conditions would be expected to persist. No machine-produced snow would be applied.

Indicator:

Modeled Anticipated Changes in the Duration and Intensity Of Annual Snowmelt Compared to Historic Natural Variation

Alternative 1 – No Action

Under the No Action alternative, input of additional water in the form of snowmaking would not occur, and no change in the annual snowmelt regime would be likely to occur.

Alternative 2 – The Proposed Action

Selection of the Proposed Action would result in snowmaking coverage on 205.2 acres of existing and proposed terrain. Of this coverage, the largest increases would occur in the following watersheds: Snowbowl (132 acres), Humphreys (28 acres) and Hart Prairie (23 acres). The proposed snowmaking coverage would require approximately 364 AF of snowmaking water use on average.

In addition to increased snowmaking coverage, implementation of the Proposed Action would involve clearing of vegetation on approximately 76.3 acres. Table 3I-11 outlines trail clearing and snowmaking coverage areas by watershed associated with the Proposed Action.

Table 3I-11
Alternative 2 Trail Clearing and Snowmaking by Watershed

Watershed	Trail Clearing (Acres)	Snowmaking Acreage
Hart Prairie	3.7	22.5
Humphreys	9.6	28.4
Lower Agassiz Ridge	7.2	12.7
Middle Agassiz Ridge	1.6	3.9
Snowbowl	54.0	131.9
Sunset	0.2	5.5
Upper Agassiz Ridge	0.0	0.3
Total	***76.3***	***205.2***

Source: Resource Engineering, Inc, 2003

Proposed activities would affect the watershed hydrology in the study area. The application of snowmaking alters the volume and timing of snowmelt. A machine-produced snowpack typically exhibits smaller grain size and higher snowpack density and water equivalent than a natural snowpack. Due to these differences in physical properties, machine-produced snow typically begins to melt later in the season than natural snow. This can increase the average duration of seasonal melt. Trail clearing affects the water balance by decreasing the amount of water removed via evapotranspiration, thus increasing the quantity of water available for infiltration or runoff. Interception and evaporation losses from the forest canopy would be reduced. Vegetation removal would affect the infiltration characteristics of the watershed, generally resulting in quicker runoff generation. Changes in vegetative cover also can affect the solar energy balance of the watershed, permitting increased solar radiation and therefore earlier and faster snowmelt. Together these changes would alter water balance characteristics and snowmelt timing.

Water Balance

The water balance model described previously under the Existing Conditions section was used to provide estimates of expected changes in the volume and distribution of water due to the Proposed Action. Summaries of the anticipated water balance changes for average, dry, and wet climatic conditions are outlined in the following tables.

Average Year Water Balance Characteristics

Table 3I-12
Alternative 2 Average Year Water Balance Characteristics

Watershed	Precipitation (AF)	Snowmaking (AF)	Watershed Loss (AF)	Recharge (AF)
Hart Prairie	1930.1	39.9	1254.0	716.0
Humphreys	784.0	50.4	451.8	382.5
Lower Agassiz Ridge	568.1	22.5	377.5	213.2
Middle Agassiz Ridge	573.5	6.9	376.7	203.7
Snowbowl	1,791.3	234.0	1,043.0	982.3
Sunset	192.7	9.8	116.7	85.7
Upper Agassiz Ridge	672.4	0.5	433.0	239.9
Total	***6,512.1***	***364.0***	***4,052.7***	***2,823.3***

Source: Resource Engineering, Inc, 2003

Table 3I-13
Alternative 2 Change in Average Year Water Balance Characteristics

Watershed	Percent Loss	Recharge Change (AF)[a]	Percent Change[a]
Hart Prairie	64%	22.8	3%
Humphreys	54%	27.5	8%
Lower Agassiz Ridge	64%	13.3	7%
Middle Agassiz Ridge	65%	3.9	2%
Snowbowl	51%	131.8	15%
Sunset	58%	4.7	6%
Upper Agassiz Ridge	64%	0.3	0%
Total	***60%***	***204.3***	***6%***

[a] Compared to existing conditions.
Source: Resource Engineering, Inc, 2003

Under the Proposed Action, introduction of additional water equivalent in the form of machine-produced snow, coupled with changes in land use due to trail construction activities, would result in a six percent increase in watershed recharge in an average year. The Snowbowl watershed, which would experience the majority of the proposed snowmaking terrain, would experience a 15 percent increase in recharge annually.

Most of the un-graded terrain at Snowbowl exhibits excellent vegetative cover, which binds root structure and stabilizes the surface soil horizon. Introduction of snowmaking water on un-graded trails would be unlikely, in and of itself, to markedly increase the erosion potential, so long as snowmaking is accompanied by implementation and maintenance of typical drainage mechanisms such as adequately spaced waterbars (see Table 2-2).

However, field review of the primary drainage within the Snowbowl watershed, in which most of the proposed snowmaking is slated to occur, reveals that surface runoff does occur during peak snowmelt conditions. Although essentially all of the observed surface flow eventually re-infiltrates into the soils, in areas where grading activity has resulted in soils turnover and compaction, surface flow has caused rilling and sedimentation.

Field review of heavily graded terrain on *Logjam* (trail #25) indicates that inadequate waterbar spacing has contributed to poor drainage routing, which has contributed to the development of concentrated surface flows, and incised rilling. Contributing to the concerns on *Logjam* (trail #25) is that the terrain modification filled in a historic flow channel, and the topography naturally concentrates flows in this vicinity. A review of graded terrain on *Upper Ridge* (trail # 26) and *Lower Ridge* (trail #21) reveals few instances of concentrated surface flow or rilling on these trails where the topographic constraints do not confine the flow of water. In general, effectively implemented and maintained drainage control mechanisms such as waterbars should adequately reduce the risk of increased erosion on graded terrain, so long as drainage control is accompanied by effective re-establishment of vegetative cover. Re-vegetation in relationship to existing and proposed graded terrain is discussed in the following section analyzing increased sediment yields due to graded terrain modification.

Dry Year Water Balance Characteristics

Table 3I-14
Alternative 2 Dry Year Water Balance Characteristics

Watershed	Precipitation (AF)	Snowmaking (AF)	Watershed Loss (AF)	Recharge (AF)
Hart Prairie	794.3	53.3	817.5	30.1
Humphreys	322.6	67.3	358.8	31.1
Lower Agassiz Ridge	233.8	30.1	263.9	0.0
Middle Agassiz Ridge	236.0	9.2	245.2	0.0
Snowbowl	737.2	312.4	927.2	122.4
Sunset	79.3	13.0	87.8	4.6
Upper Agassiz Ridge	276.7	0.7	277.4	0.0
Total	***2,679.9***	***486.0***	***2,977.8***	***188.2***

Source: Resource Engineering, Inc, 2003

Table 3I-15
Alternative 2 Change in Dry Year Water Balance Characteristics

Watershed	Percent Loss	Recharge Change (AF)	Percent Change
Hart Prairie	96%	4.2	16%
Humphreys	92%	4.0	15%
Lower Agassiz Ridge	100%	0.0	0%
Middle Agassiz Ridge	100%	0.0	0%
Snowbowl	88%	22.8	23%
Sunset	95%	0.1	2%
Upper Agassiz Ridge	100%	0.0	0%
Total	***96%***	***31.1***	***8%***

Source: Resource Engineering, Inc, 2003

Overall, an eight percent increase in annual recharge would be anticipated during dry-year conditions, although for the Agassiz ridge watersheds, both existing and Alternative two conditions reflect 100 percent watershed losses in the dry-year scenario. For the primary snowmaking watershed, a 23 percent increase in recharge would occur. The following tables show anticipated water balance characteristics in the wet-year scenario.

Wet Year Water Balance Characteristics

Table 3I-16
Alternative 2 Wet Year Water Balance Characteristics

Watershed	Precipitation (AF)	Snowmaking (AF)	Watershed Loss (AF)	Recharge (AF)
Hart Prairie	2941.8	26.6	1311.5	1656.9
Humphreys	1,194.9	33.6	461.3	767.2
Lower Agassiz Ridge	865.9	15.0	398.7	482.3
Middle Agassiz Ridge	874.1	4.6	384.6	494.1
Snowbowl	2,730.2	156.2	1,090.1	1,796.3
Sunset	293.8	6.5	121.6	178.7
Upper Agassiz Ridge	1,024.9	0.4	446.0	579.3
Total	***9,925.6***	***242.9***	***4,213.8***	***5,954.8***

Source: Resource Engineering, Inc, 2003

Table 3I-17
Alternative 2 Change in Wet Year Water Balance Characteristics

Watershed	Percent Loss	Recharge Change (AF)[a]	Percent Change[a]
Hart Prairie	44%	11.5	1%
Humphreys	38%	15.7	2%
Lower Agassiz Ridge	45%	0.0	0%
Middle Agassiz Ridge	44%	6.0	1%
Snowbowl	38%	42.3	2%
Sunset	40%	2.4	1%
Upper Agassiz Ridge	43%	0.1	0%
Total	***42%***	***78.0***	***1%***

[a] Compared to existing conditions.
Source: Resource Engineering, Inc, 2003

In a wet year, snowmaking represents a very small percentage of the overall water balance. For the Snowbowl watershed, receiving most of the snowmaking input, the change in recharge compared to existing conditions is two percent.

Alternative 3

Implementation of Alternative 3 would not include snowmaking coverage within the Snowbowl SUP area. However, implementation of Alternative 3 would entail trail construction involving clearing of vegetation on approximately 64 acres. Table 3I-18 outlines the trail construction acreage totals associated with the Alternative 3.

Table 3I-18
Alternative 3 Trail Clearing

Watershed	Trail Clearing (ares)
Hart Prairie	1.6
Humphreys	2.0
Lower Agassiz Ridge	7.2
Middle Agassiz Ridge	1.6
Snowbowl	51.4
Sunset	0.2
Upper Agassiz Ridge	0.0
Total	***64.0***

Source: Resource Engineering, Inc., 2003

Trail clearing affects the water balance by decreasing the amount of water removed via evapotranspiration, thus increasing the quantity of water available for runoff. Interception and evaporation losses from the forest canopy would be reduced. Vegetation removal would affect the infiltration characteristics of the watershed, generally resulting in quicker runoff generation. Changes in vegetative cover also can affect the solar energy balance of the watershed, permitting increased solar radiation and therefore earlier and faster snowmelt. Vegetation removal would alter the water balance characteristics and snowmelt timing.

Water Balance

The following tables outline the effects of the proposed trail construction activities under Alternative 3 on the surface water balance for the various project area watersheds in an average year.

Average Year Water Balance Characteristics

Table 3I-19
Alternative 3 Average Year Water Balance Characteristics

Watershed	Precipitation (AF)	Snowmaking (AF)	Watershed Loss (AF)	Recharge (AF)
Hart Prairie	1930.1	0.0	1236.9	693.1
Humphreys	784.0	0.0	428.2	355.8
Lower Agassiz Ridge	568.1	0.0	365.3	202.8
Middle Agassiz Ridge	573.5	0.0	373.1	200.4
Snowbowl	1,791.3	0.0	919.0	872.3
Sunset	192.7	0.0	111.6	81.2
Upper Agassiz Ridge	672.4	0.0	432.8	239.7
Total	***6,512.1***	***0.0***	***3,866.9***	***2,645.3***

Source: Resource Engineering, Inc, 2003

Table 3I-20
Alternative 3 Change in Average Year Water Balance Characteristics

Watershed	Percent Loss	Recharge Change (AF)[a]	Percent Change[a]
Hart Prairie	64%	0.0	0%
Humphreys	55%	0.8	0%
Lower Agassiz Ridge	64%	3.0	1%
Middle Agassiz Ridge	65%	0.6	0%
Snowbowl	51%	21.8	3%
Sunset	58%	0.1	0%
Upper Agassiz Ridge	64%	0.0	0%
Total	***60%***	***26.3***	***1%***

[a] Compared to existing conditions.
Source: Resource Engineering, Inc, 2003

In comparison to the combined effects of both snowmaking and trail clearing, the areas of trail construction alone proposed under Alternative 3 represent a fairly minor change in the annual water balance of one percent. The Snowbowl watershed, slated to receive most of the proposed trail construction, would experience a three percent change in the annual water balance.

Dry Year Water Balance Characteristics

Table 3I-21
Alternative 3 Dry Year Water Balance Characteristics

Watershed	Precipitation (AF)	Snowmaking (AF)	Watershed Loss (AF)	Recharge (AF)
Hart Prairie	794.3	0.0	776.7	25.9
Humphreys	322.6	0.0	294.8	27.9
Lower Agassiz Ridge	233.8	0.0	233.8	0.0
Middle Agassiz Ridge	236.0	0.0	236.0	0.0
Snowbowl	737.2	0.0	614.8	122.4
Sunset	79.3	0.0	74.7	4.6
Upper Agassiz Ridge	276.7	0.0	276.7	0.0
Total	***2,679.9***	***0.0***	***2,507.5***	***180.8***

Source: Resource Engineering, Inc, 2003

Table 3I-22
Alternative 3 Change in Dry Year Water Balance Characteristics

Watershed	Percent Loss	Recharge Change (AF)[a]	Percent Change[a]
Hart Prairie	98%	0.0	0%
Humphreys	91%	0.8	3%
Lower Agassiz Ridge	100%	0.0	0%
Middle Agassiz Ridge	100%	0.0	0%
Snowbowl	83%	22.8	23%
Sunset	94%	0.1	2%
Upper Agassiz Ridge	100%	0.0	0%
Total	***95%***	***23.7***	***4%***

a. Compared to existing conditions.
Source: Resource Engineering, Inc, 2003

During dry years, the Snowbowl watershed, experiencing most of the proposed trail construction, would experience a 23 percent increase in recharge as compared to existing conditions. Changes in vegetative cover would be likely to increase the potential for surface runoff occurrence, which would subsequently re-infiltrate into the soils.

Wet Year Water Balance Characteristics

Table 3I-23
Alternative 3 Wet Year Water Balance Characteristics

Watershed	Precipitation (AF)	Snowmaking (AF)	Watershed Loss (AF)	Recharge (AF)
Hart Prairie	2941.8	0.0	1296.3	1645.4
Humphreys	1,194.9	0.0	442.6	752.3
Lower Agassiz Ridge	865.9	0.0	380.7	485.2
Middle Agassiz Ridge	874.1	0.0	385.4	488.7
Snowbowl	2,730.2	0.0	954.6	1,775.6
Sunset	293.8	0.0	117.4	176.4
Upper Agassiz Ridge	1,024.9	0.0	445.7	579.1
Total	***9,925.6***	***0.0***	***4,022.7***	***5,902.7***

Source: Resource Engineering, Inc, 2003

Table 3I-24
Alternative 3 Change in Wet Year Water Balance Characteristics

Watershed	Percent Loss	Recharge Change (AF)[a]	Percent Change[a]
Hart Prairie	44%	0.0	0%
Humphreys	37%	0.8	0%
Lower Agassiz Ridge	44%	2.9	1%
Middle Agassiz Ridge	44%	0.6	0%
Snowbowl	35%	21.6	1%
Sunset	40%	0.1	0%
Upper Agassiz Ridge	43%	0.0	0%
Total	***41%***	***26.0***	***0%***

[a] Compared to existing conditions.
Source: Resource Engineering, Inc, 2003

Under Alternative 3, during wet year conditions, the changes in vegetation caused by trail construction activities would result in water balance changes that would be minor fractions of the overall water input in a wet year. The Snowbowl watershed, experiencing most of the proposed trail construction, would experience a one percent increase in recharge as compared to existing conditions.

Indicator:

Modeled Anticipated Changes in Erosion/Sedimentation Due to Predicted Changes in Total Snowpack.

Alternative 1 – No Action

Under the No Action alternative, new trail construction or grading would occur, and no changes in erosion or sedimentation would be expected.

Alternative 2 – The Proposed Action

In order to quantify the potential sediment yield associated with the proposed ground disturbance, the USDA-ARS Water Erosion Prediction Project (WEPP) model was applied to compute increases in sediment detachment for trail construction and improvement areas where grading would be applied, as well as areas of new road construction/improvements.

There are several primary effects to soil resources associated with graded terrain modifications. Grading and re-contouring utilizing heavy machinery causes soils compaction and loss of soil tilth. Loss of top soil and a decrease in soils organic matter associated with disturbances to the rooting zone can reduce the soils productivity. Lastly, soils disturbances, coupled with increased water inputs in the form of snowmaking, increase the risk of soil particle detachment and transport due to surface water erosion, increasing sediment yields.

The Forest Service has developed a set of forest simulation parameters for WEPP based on model calibration and validation to observed forested watershed behavior. These custom WEPP parameters are described in *Water Erosion Prediction Project Forest Applications*.[312] The WEPP model is a process-based, continuous computation, distributed parameter erosion prediction model implemented as a computer numerical simulation.[313] The model is based on numerical representations of the physical processes influencing runoff and sediment yield. Thus, it permits a simulation of various actual watershed processes, including: rainfall/snowfall, infiltration, runoff, soil moisture accounting, snow accumulation/melt, evapotranspiration, plant growth and litter decomposition, and sediment detachment and deposition. The model parameters include rainfall amounts and intensity, soil textural properties, plant growth parameters, residue decomposition factors, slope shape, steepness, and orientation, and soil erodibility parameters. Soils may be represented in multiple layers with multiple parameters describing texture, rock content, moisture, permeability, organic content, and cation exchange capacity. The model uses a statistically generated synthetic climate dataset to drive its simulations. The synthetic dataset is derived by applying a probabilistic model

[312] Elliot, William J and David E. Hall, 1997

[313] USDA Forest Service, 2000

using statistical parameters computed from observed climate trends. High resolution climate data (including temperature, wind speed and direction, relative humidity, and solar radiation) is derived via a sophisticated spatial algorithm. The PRISM climate data modeling process interpolates these variables based on both geographic position and elevation, from proximal NOAA, BLM RAWS, and NRCS-SNOTEL climate stations.

The soil type chosen for simulation within WEPP was a “sandy loam.” CNF Terrestrial Ecology Survey mapping within the Snowbowl SUP confirm that the andesite/dacite-derived soils in the Snowbowl watersheds are sandy loams.

The WEPP model treats hillslope erosion and sediment detachment by modeling overland flow elements (OFE’s). The OFE’s allow the model to describe different treatment prescriptions, e.g. an upper OFE modeling a disturbed area, delivering sediment into and through a lower OFE which could model a vegetated buffer region.

The WEPP model was executed over a simulation period of 30 years. The model simulations were driven by climatic data derived from the PRISM model, corresponding to average-year conditions. The event-based model output includes rainfall events statistically generated by the USDA-ARS CLIGEN package to produce the synthetic climate dataset, and runoff events resulting from either rainfall or snowmelt. In order to simulate snowmaking water inputs under Alternative 2, the CLIGEN precipitation input was modified to reflect increased precipitation water input commensurate to the proposed quantities of snowmaking water equivalent.

The sediment yield predictions from this simulation period offer an average and maximum value for soil detachment. It should be noted that the model is run over a 30-year period using the same treatment prescription to provide a dataset of sufficient length to compute averages and return periods. The results from a 30-year simulation should not be interpreted to be potential erosion rates for full a 30-year time period following construction. Another factor of note when interpreting the model results is that the model assumes that the full area of construction is disturbed at any one time during the simulation process. In practice, disturbances associated with terrain modification would be phased over a number of years and would thereby minimize the overall extent of disturbance at any point in time.

For purposes of modeling sediment production, only graded and re-contoured areas of *new* grading, re-contouring, or ground disturbance are considered in the WEPP modeling process. Therefore, the modeled results represent potential changes or increases in detachment due to various project elements.

To facilitate the analysis for graded terrain, the surface hydraulic conductivity was selected to be a comparatively low value of 3.5 millimeters per hour to reflect the soil compaction and decreased infiltration exhibited by areas of terrain grading and re-contouring. In order to assess the potential sediment detachment associated with the proposed terrain modifications, the WEPP model was executed for three different land cover prescriptions, alternatively modeling sediment production under the following scenarios through time:

1. **<u>Post-Disturbance</u>**
   Selected Land Cover Prescription: Mechanically disturbed & compacted soils
   Cover Density: 0 percent
   Surface Rock Fraction: 35 percent

2. **<u>Re-vegetated Conditions (1-4 years)</u>**
   Selected Land Cover Prescription: Short Grass
   Cover Density: 35 percent
   Surface Rock Fraction: 35 percent

3. **<u>Future Conditions (5-10 Years)</u>**
   Selected Land Cover Prescription: Tall Grass
   Cover Density: 40 percent
   Surface Rock Fraction: 35 percent

Each of these treatment prescriptions was modeled for a representative 250 foot hillslope upper OFE transitioning into a lower OFE "buffer" of short grass, which can be conceptualized as a vegetated buffer strip. Model runs for each of the above three prescriptions were performed for each of several slope gradients, as described below.

Because land slope is one of the primary determinants driving the potential for detachment of soil particles under the influence of water-driven erosional processes, the graded areas were subdivided into zones by slope gradient as follows:

- 0 - 10 percent slope gradient
- 10 - 20 percent slope gradient
- 20 - 30 percent slope gradient
- 30 - 40 percent slope gradient
- Greater than 40 percent slope gradient

In addition to the above process for modeling regions of trail construction, sediment yield modeling for the new road segment associated with the snowmaking pond access road was performed using the WEPP: Road module, which specifically models sediment detachment and transport from road surfaces on forested lands. The road segment was modeled as a native surface, out-sloped road. Obviously, in modeling road sediment production through time, it was assumed to be a permanent additional sediment source, whose detachment rates do not decrease through time.

The breakdown of graded terrain by slope class for the Proposed Action is outlined in the following table.

Table 3I-25
Alternative 2 Graded Terrain By Slope Class

Soil Unit	<10% (Acres)	10 - 20 % (Acres)	20 - 30 % (Acres)	30 - 40 % (Acres)	> 40% (Acres)	Total[a] (Acres)
Grading						
640	4.4	12.9	5.9	2.2	0.2	**25.6**
715	0.4	1.3	0.2	0.0	0.0	**1.9**
740	2.7	19.1	23.2	12.2	4.6	**61.7**
770	0.0	0.5	1.1	3.1	12.6	**17.3**
785	0.2	3.7	8.1	5.3	2.5	**19.9**
850	0.1	1.9	1.9	0.5	0.0	**4.5**
Road Construction						
715	1.0	0.5	0.0	0.0	0.0	**1.6**
740	0.8	1.2	0.1	0.0	0.0	**2.0**
Total	***7.8***	***39.5***	***40.3***	***23.4***	***19.9***	***130.9***[a]

[a] Note: The total graded area reported in this table is greater than that reported in Table 2-4 (Alternatives Matrix/Summary of Environmental Consequences) table in Chapter 2. The reason for this difference is that the graded areas within this table encompass multiple disturbance types, including utility corridors, etc. Therefore, this table considers potential erosion effects caused by all varieties of ground-disturbing activities.
Source: Resource Engineering, Inc., 2003

The options for treatment prescription and slope gradient classes were subsequently used as input to the WEPP model to produce predictions for potential sediment yield. The model results are outlined in the Table 3I-26.

Table 3I-26
Alternative 2 WEPP Model Predicted Erosion Rate
(Slope Class, Tons/Acre)

Slope Gradient (%)	Post Disturbance	After Re-Vegetation, Years 2-5[a]	After Re-Vegetation, Years 6 Onward[a]
<10%	0.05	0.4	0.1
10 - 20 %	0.44	1.7	0.8
20 - 30 %	1.4	2.7	1.3
30 - 40 %	4.4	3.5	1.7
>40%	14.8	4.3	2.1

[a] Note: Years 2-5 utilize the Disturbed WEPP Short Grass management prescription, while year six and onward utilize the Tall Grass management prescription. For slopes less than 30%, WEPP predicts more erosion for the re-vegetated prescriptions than for the skid trail prescription utilized for post-disturbance circumstances. Although this result is counter-intuitive, no adjustments were made during the modeling process, in order to avoid arbitrary adjustment of input parameters, and to maintain a conservative and defensible analysis.
Source: Resource Engineering, Inc, 2003

In implementation, WEPP models hillslope erosional processes, and produces site-specific predictions for both sediment detachment and sediment deposition at each model increment along both the upper and lower OFE. Thus WEPP is capable of predicting the quantity of sediment that ultimately transports through a given vegetated buffer. In practice, modeling each individual hillslope component for every region of terrain modification in the Proposed Action was impractical. Therefore, the general model results for sediment detachment per unit area (tons per acre) for each combination of prescription and slope gradient as outlined in Table 3I-25 were selectively multiplied by the graded areas (acres) categorized by slope class as outlined in Table 3I-26, to yield predictions of sediment yield (tons) per graded area as provided in Table 3I-27.

Table 3I-27
Proposed Action Graded Areas
Potential Increased Sediment Detachment
Above Existing Conditions

Soil Unit	Post Implementation (tons)	Post Re-Vegetation (Years 2-5[a]) (tons)	Post Re-Vegetation (Years 6 Onward[a]) (tons)
Grading			
640	26.3	48.0	22.5
715	0.9	2.9	1.3
740	162.6	158.5	76.1
770	201.6	68.7	33.5
785	74.2	58.0	28.0
850	6.4	10.3	4.9
Total Detachment Grading	**471.9**	**346.6**	**166.3**
Road			
715	2.2	2.2	2.2
740	23.3	23.3	23.3
Total Detachment Road	**25.5**	**25.5**	**25.5**
Road De-Commissioning			
715	**-14.3**	**-14.3**	**-14.3**
Total Detachment	***483.1***	***357.8***	***177.5***

[a] No re-vegetation was assumed to occur for road surface.
Source: Resource Engineering, Inc, 2003

While the sediment detachment quantities predicted by the WEPP are measures of potential detachment, and not actual sediment yield or delivery, the anticipated increase in post-implementation detachment of 483 tons is substantial. After re-vegetation, even with de-commissioning of a portion of the existing mountain access road reducing detachment by approximately 14 tons per year, the total increase in detachment is anticipated to be almost 180 tons. This increase is driven primarily by 43.3 acres of the 131 acres of total disturbance that are proposed to occur on slopes of 30 percent slope gradient or higher. Furthermore, five of the six affected soils mapping units have erosion hazards rated as “Severe,” while re-vegetation potential is rated as Low to Moderate.

Re-establishment of vegetative cover is of critical importance for control of potential erosion from graded terrain. Field review of graded terrain on the *Logjam* (trail #25) and *Upper Ridge* (trail #26) trails, where grading has occurred within the last six to 10 years, reveals that re-vegetation over that time period has yielded typical vegetation cover densities of only 15 to 20 percent. The surface rock fraction for graded terrain is higher, and loss of topsoil has resulted due to the turnover of graded soils. On existing graded trails, in areas where finer-grained soil particles have settled, re-vegetation has resulted in somewhat higher cover densities, ranging from 30 to 40 percent. The assumptions utilized for the WEPP analysis incorporate a long-term re-vegetation cover fraction attainment of 40 percent. For comparison, existing trails which have been flush-cut exhibit excellent vegetative cover, with cover densities ranging from 70 to 80 percent, and well-established (although rocky) topsoils.

In order to sufficiently reduce the risk of increased soil loss, and reach the 40 percent long-term cover densities assumed in the WEPP model, attainment of adequate re-establishment of vegetative cover would be essential. Stockpiling of topsoil prior to grading, preservation, and re-distribution following grading, accompanied by mulching and re-vegetation, would likely result in improved re-vegetation in comparison to existing graded terrain, especially on gentler slopes (less than 30 percent slope gradient). In these areas, post-grading erosion risk would be moderate.

However, a review of Table 3I-26 reveals that for areas with greater than 30 percent slope gradient, potential immediate post-disturbance sediment detachment rates range from approximately 3 to 10 times those exhibited by slopes in the 20 to 30 percent range. Coupled with the severe erosion hazard for the affected soils units, the risk of topsoil loss is severe. Table 2-2 (Mitigation Measures and Best Management Practices) in Chapter 2 outlines several specific erosion control measures, such as jute-netting or geo-textile mesh, designed to enhance soils stabilization and re-vegetation potential for these steeper slopes. Successful implementation of such measures can reduce, but not eliminate the high risk of erosion and topsoil loss on steeper slopes. Successful and secure installation of these measures can be difficult on steeper terrain. Thus, the risk of erosion and topsoil loss following grading on slopes with gradients of 30 percent or greater would likely be moderate to high.

In interpreting the sediment yield predictions, it is important to note that the quantities refer to sediment detachment, and do not represent actual delivery of sediment to stream systems within the watersheds. Furthermore, the WEPP documentation cautions that "At best, any predicted runoff or erosion value, by any model, will be within only plus or minus 50 percent of the [actual] value. Erosion rates are highly variable, and most models can predict only a single value. Replicated research has shown that observed values vary widely for identical plots, or the same plot from year-to-year. Also, spatial variability… of soil properties add[s] to the complexity of erosion prediction."[314]

Alternative 3

Under Alternative 3, there are slight differences in the areas proposed for grading. Because snowmaking would not be implemented, no road would be constructed from the existing maintenance facility to the snowmaking water impoundment location, nor would the impoundment construction create ground disturbance. Further, additional water input in the form of snowmaking would not occur on the graded terrain. The breakdown of graded terrain by slope class for Alternative 3 is outlined in the Table 3I-28.

[314] USDA Forest Service, 2000

Table 3I-28
Alternative 3 - Graded Terrain By Slope Class

Soil Unit	<10% (acres)	10 - 20 % (acres)	20 - 30 % (acres)	30 - 40 % (acres)	> 40% (acres)	Total (acres)
640	2.7	10.2	5.6	2.2	0.2	**20.8**
715	0.2	0.5	0.1	0.0	0.0	**0.9**
740	1.9	14.9	21.8	12.2	4.6	**55.3**
770	0.0	0.5	1.1	3.1	12.6	**17.3**
785	0.2	3.7	8.1	5.3	2.5	**19.9**
850	0.1	1.9	1.9	0.5	0.0	**4.5**
Total	***5.1***	***31.7***	***38.5***	***23.3***	***19.9***	***118.6***[a]

[a] Note: The total graded area reported in this table is greater than that reported in Table 2-4 (Alternatives Matrix/Summary of Environmental Consequences) table in Chapter 2. The reason for this difference is that the graded areas within this table encompass multiple disturbance types, including utilities corridors, etc. Therefore, this table considers potential erosion effects caused by a variety of ground-disturbing activities.
Source: Resource Engineering, Inc, 2003

The options for treatment prescription and slope gradient classes were subsequently used as input to the WEPP model to produce predictions for potential sediment yield. The model results are outlined in Table 3I-29.

Table 3I-29
Alternative 3 - WEPP Model Predicted Erosion Rate
(by Slope Class, Tons/Acre)

Slope Gradient (%)	Post Disturbance (tons/acre)	After Re-Vegetation, Years 2-5 (tons/acre)[a]	After Re-Vegetation, Years 6 Onward (tons/acre)[a]
< 10%	0.05	0.4	0.1
10 - 20 %	0.44	1.7	0.8
20 - 30 %	1.4	2.7	1.3
30 - 40 %	4.4	3.5	1.7
> 40%	14.8	4.3	2.1

[a]Note: Years 2-5 utilize the Disturbed WEPP Short Grass management prescription, while years 6 onward utilize the Tall Grass management prescription. For slopes less than 30%, WEPP predicts more erosion for the re-vegetated prescriptions than for the skid trail prescription utilized for post-disturbance circumstances. Although this result is counter-intuitive, no adjustments were made during the modeling process, in order to avoid arbitrary adjustment of input parameters, and to maintain a conservative and defensible analysis.
Source: Resource Engineering, Inc, 2003

The general model results for sediment detachment per unit area (tons per acre) for each combination of prescription and slope gradient as outlined in Table 3I-28 were selectively multiplied by the graded areas (acres) categorized by slope class as outlined in Table 3I-29, to yield predictions of sediment yield (tons) per graded area, as provided in Table 3I-30.

Table 3I-30
Alternative 3 Graded Areas
Potential Increased Sediment Detachment
Above Existing Conditions

Soil Unit	Post Implementation (tons)	After Re-Vegetation, Years 2-5 (tons)	After Re-Vegetation, Years 6 Onward (tons)
Grading			
640	24.5	41.8	19.7
715	0.4	0.0	0.0
740	158.6	147.2	70.7
770	201.6	68.7	33.5
785	74.2	58.0	28.0
850	6.4	10.3	4.9
Total Detachment	***465.6***	***327.3***	***157.5***

Source: Resource Engineering, Inc, 2003

The anticipated increase in detachment immediately following project implementation is approximately 466 tons, and is four percent lower than the Proposed Action The detachment rates are driven primarily by 42 acres of the 119 acres of total grading that are proposed to occur on slopes of 30 percent slope gradient or higher. Furthermore, five of the six affected soils mapping units have erosion hazards rated as “Severe,” while re-vegetation potential is rated as Low to Moderate.

In order to sufficiently reduce the risk of increased soil loss, and reach the 40 percent long-term cover densities assumed in the WEPP model, attainment of adequate re-establishment of vegetative cover would be essential. Stockpiling of topsoil prior to grading, preservation, and re-distribution following grading, accompanied by mulching and re-vegetation, would likely result in improved re-vegetation in comparison to existing graded terrain, especially on gentler slopes (less than 30 percent slope gradient). In these areas, post-grading erosion risk would be moderate.

However, a review of Table 3I-29 reveals that for slopes with greater than 30 percent slope gradient, potential immediate post-disturbance sediment detachment rates range from approximately 3 to 10 times those exhibited by slopes in the 20 to 30 percent range. Coupled with the severe erosion hazard for the affected soils units, the risk of topsoil loss is severe. Table 2-2 (Mitigation Measures and Best Management Practices) in Chapter 2 outlines several specific erosion control measures, such as jute-netting or geo-textile mesh, designed to enhance soils stabilization and re-vegetation potential for these steeper slopes. Successful implementation of such measures can reduce, but not eliminate the high risk of erosion and topsoil loss on steeper slopes. Successful and secure installation of these measures can be difficult on steeper terrain. Thus, the risk of erosion and topsoil loss following grading on slopes with gradients of 30 percent or greater would likely be moderate to high.

Indicator:

Analysis of Potential Changes to Soil Chemistry Due to Anticipated Increases in Soil Moisture Consistency and Nutrient Loading

Alternative 1 – No Action

Under the No Action alternative, input of additional water in the form of snowmaking would not occur, and no change in the soil chemistry regime would be likely to occur.

Alternative 2 – The Proposed Action

Summary of the Analysis Procedure

The following analysis is excerpted from the soils column test report produced by ESN Rocky Mountain.[315] The entire report is contained in the official project record. Soils sampling and laboratory analyses were performed in order to assess the potential changes in soil chemistry resulting from the introduction of tertiary-treated reclaimed municipal wastewater in the form of machine-produced snow. Undisturbed, intact, soil cores were collected from a location at the base of slope areas within the SUP area using a "direct push" drilling methods. One undisturbed core was also collected from two to three feet with a California Geotechnical Sampler, in order to test for soils' physical properties. The depth of the cores ranged from 8 to 11 feet

The site from which the cores were obtained is approximately 900 feet east (upslope) of the existing lower terminal of the Agassiz Lift. The site is located within soils mapping unit 740, within the primary watershed drainage slated to receive snowmaking water input under the Proposed Action. The soils are classified as "Andic Cryoborolls." In descending order, the soil profile used in the column experiment consists of a well-decomposed A-horizon, a zone of eluviation (Ae), and B-horizon and C-horizon andesitic parent material.

The soils and parent material retrieved were used to re-construct the "in-situ" soil profile in a 10-foot long PVC column in the laboratory. This column was used to conduct a loading test on the soil using treated wastewater from the City of Flagstaff. Initial baseline soil chemistry was analyzed utilizing representative composited samples from each of the major soils horizons (A, B, and C).

Subsequently, approximately 44 gallons of treated wastewater were percolated through the soil column over a period of roughly 60 hours. This volume is equivalent to 67.6 feet of treated wastewater application to the soil and does not take into account dilution from natural snowfall. The volume corresponds to 38 years of seasonal snowmaking application, for average operational conditions.

Two sets of water samples were collected at different stages of the test. Water samples were drawn from valves installed along the soil column at the A/B and B/C horizon boundaries, as well as at the bottom of the column. Early percolation samples were collected after 6.6 gallons had been pumped through the column. Late percolation water samples were collected after 41 gallons of treated water had passed through the column.

[315] ESN Rocky Mountain, 2003

Once percolation was complete, the soil column was de-constructed and composite soil samples were collected from each horizon, in order to assess the resultant soils chemistry.

Physical Properties of the Soils

Some settling occurred in the column after water pumping commenced. The resulting length of each horizon (after settling) is shown below in Table 3I-31. Also shown is the weight of material removed from the column after separating each horizon and the sand pack intervals. Densities in the column were calculated based on the corrected dry weight of the soil removed from each horizon. The density can be compared to the core densities from the geotechnical sample (Refer to Table 3I-32) collected at the site.

Table 3I-31
Soils Column Physical Properties

Soil Horizon Column Section Units	Wet Soil Weight (pounds)	Post-run Soil Moisture (percent)	Calc. Dry Basis Soil Weight (pounds)	Settled Soil Depth (inches)	Dry Basis Soil Density (g/cm^3)
A	12	27.4	8.8	16.0	1.20
B	37	13.9	32.0	51.8	1.35
C	26	22.5	20.1	34.0	1.31
Total	***75***			***102***	

Source: ESN Rocky Mountain, 2003

Table 3I-32
Moisture and Density from Advanced Terra Testing

Core Section Units	Wet Density (lb/ft^3)	Percent Moisture (percent)	Dry Density (lb/ft^3)	Dry Density (g/cm^3)
A	122	13.9	107	1.71
B	112	8.0	104	1.67
C	114	7.0	107	1.71
D	116	5.1	110	1.76

Source: ESN Rocky Mountain, 2003

Soils Baseline and Post-Percolation Chemical Analysis

An evaluation of the soil column analytical results was carried out to:

Document variations in fecal bacteria, and trace and major cations and anions.
Assess the environmental impact of these variations on the treated water and flushed soils.

The soil horizons and treated water were sampled and analyzed both before and after percolation of the treated wastewater. The variations of bacteria and trace and major anions and cations in the water and soils were examined both before and after percolation The analytical results for the water and soils are also provided in the following tables.

Table 3I-33
Column Test Soils Chemistry

Method Employed		NCA 0103	EPA SW-846 9045C		HACH 9056	SM-4500	9060	SW-846 6010B				
LIMS ID	Sample ID	% Moisture	pH	Fecal Coliform	Total Phosphate	N-Ammonia	TOC	Sb	As	Ba	Be	Cd
Units		%		MPN/100 g	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
101293-0001	Initial A	4.58	6.45	400	5083	< 8	1.70	< 50	< 50	188	< 2.5	< 5
101293-0002	Initial B	1.36	7.12	< 20	3802	< 8	0.37	23	32	93	< 1.0	< 2
101293-0003	Initial C	2.28	8.84	< 20	4554	< 8	0.19	16	19	76	0.9	< 1
101293-0004	Final A	27.40	7.48	< 20	4683	< 8	1.95	< 20	< 20	159	< 1.0	< 2
101293-0005	Final B	13.90	7.50	< 20	5168	< 8	0.30	20	23	68	< 0.5	< 1
101293-0006	Final C	22.50	9.30	< 20	4710	< 8	0.23	14	20	93	0.7	< 1

Method Employed		SW-846 6010B										
LIMS ID	Sample ID	Ca	Cr	Cu	Pb	Mg	Ni	K	Se	Ag	Na	Sr
Units		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	Mg/kg
101293-0001	Initial A	6003	12	17.1	< 25.00	6414	21	1413	< 125	< 5	< 1250	57
101293-0002	Initial B	5031	11	16.3	11.15	6613	16	576	< 50	< 2	< 500	42
101293-0003	Initial C	6667	7	14.5	8.29	6626	15	528	< 25	< 1	1571	49
101293-0004	Final A	5691	10	15.3	< 10.00	5930	17	1209	< 50	< 2	< 500	42
101293-0005	Final B	4422	8	14.0	8.01	6516	14	533	< 25	< 1	328	33
101293-0006	Final C	7194	5	10.8	9.03	5539	11	529	< 25	< 1	1938	47

Method Employed		SW-846 6010B		EPA SW-846 7471A	EPA SW-846 9056						EPA SW846 1664	
LIMS ID	Sample ID	Tl	Zn	Hg	Br	Cl	F	SO_4	NO_3	NO_2	O&G	
Units		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	
101293-0001	Initial A	< 100	63	< 0.03	< 1.0	6	< 1.0	2	51.0	< 1.0	52	
101293-0002	Initial B	< 40	55	< 0.03	< 1.0	1	< 1.0	< 2	< 1.0	< 1.0	64	
101293-0003	Initial C	< 30	45	< 0.03	< 5.0	13	< 5.0	84	< 5.0	< 5.0	56	
101293-0004	Final A	< 50	58	< 0.03	< 1.0	26	< 1.0	8	< 1.0	< 1.0	59	
101293-0005	Final B	< 50	49	< 0.03	< 1.0	10	< 1.0	6	2.0	< 1.0	< 25	
101293-0006	Final C	< 50	37	< 0.03	< 5.0	13	< 5.0	39	< 5.0	< 5.0	126	

Table 3I-34
Column Test Water Chemistry

Method Employed		EPA SW-846 9045C			8048		EPA SW-846 9056	SM-4500		SW-846 6010B			
LIMS ID	**Sample ID**	**pH**	**TDS**	**Fecal Coliform**	**Total Phosphate**	**Dissolved Phosphate**	**Ortho-phostphate**	**N-Ammonia**	**TOC**	**Sb**	**As**	**Ba**	**Be**
Units			**mg/L**	**MPN/100 ml**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
101277-0001	Initial Water	7.47	394	< 2	< 0.5	< 0.5	< 2.00	< 0.8	4.8	<0.1	<0.1	0.27	< 0.005
101277-0002	Early Water (A/B)	6.44	349	7	< 0.5	< 0.5	< 2.00	< 0.8	12.9	<0.1	<0.1	0.26	< 0.005
101277-0003	Early Water (B/C)	6.59	355	< 2	< 0.5	< 0.5	< 2.00	< 0.8	5.8	<0.1	<0.1	0.17	< 0.005
101277-0004	Early Water (Bot. C)	7.08	558	< 2	< 0.5	< 0.5	< 2.00	< 0.8	7.9	<0.1	<0.1	0.22	< 0.005
101277-0005	Late Water (A/B)	7.17	390	14	< 0.5	< 0.5	< 2.00	< 0.8	12	<0.1	<0.1	0.26	< 0.005
101277-0006	Late Water (B/C)	6.98	387	< 2	< 0.5	< 0.5	< 2.00	< 0.8	5.3	<0.1	<0.1	0.14	< 0.005
101277-0007	Late Water (Bot. C)	7.71	404	< 2	< 0.5	< 0.5	< 2.00	< 0.8	5.2	<0.1	<0.1	0.13	< 0.005
101277-0008	Final Water	7.44	396	2	< 0.5	< 0.5	< 2.00	< 0.8	5.3	<0.1	<0.1	0.12	< 0.005

Method Employed		EPA SW-846 6010B											
LIMS ID	**Sample ID**	**Cd**	**Ca**	**Cr**	**Cu**	**Pb**	**Mg**	**Ni**	**K**	**Se**	**Ag**	**Na**	**Sr**
Units		**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
101277-0001	Initial Water	< 0.01	32	< 0.005	0.013	< 0.05	17	0.030	14	< 0.25	0.015	91	0.10
101277-0002	Early Water (A/B)	< 0.01	19	< 0.005	0.013	< 0.05	4	< 0.025	18	< 0.25	0.012	87	0.18
101277-0003	Early Water (B/C)	< 0.01	23	< 0.005	0.012	< 0.05	9	0.031	13	< 0.25	0.013	67	0.25
101277-0004	Early Water (Bot. C)	< 0.01	26	< 0.005	0.017	< 0.05	6	0.031	9	< 0.25	0.014	165	0.27
101277-0005	Late Water (A/B)	< 0.01	31	< 0.005	0.015	< 0.05	16	0.037	13	< 0.25	0.015	87	0.25
101277-0006	Late Water (B/C)	< 0.01	26	< 0.005	0.011	< 0.05	12	0.033	12	< 0.25	0.012	3	0.25
101277-0007	Late Water (Bot. C)	< 0.01	26	< 0.005	0.011	< 0.05	11	0.029	11	< 0.25	0.012	90	0.25
101277-0008	Final Water	< 0.01	24	< 0.005	0.011	< 0.05	8	0.031	11	< 0.25	0.011	100	0.23

Table 3I-34, Continued
Column Test Water Chemistry

Method Employed		EPA SW-846 6010B		EPA SW-846 7471A	EPA SW-846 9056						EPA SW846 1664
LIMS ID	Sample ID	Tl	Zn	Hg	Br	Cl	F	SO_4	NO_3	NO_2	O&G
	Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
101277-0001	Initial Water	< 0.2	0.08	< 0.0005	< 1.0	101	< 1.0	22	20	< 1.0	1.0
101277-0002	Early Water (A/B)	< 0.2	0.06	< 0.0005	< 1.0	102	< 1.0	22	21	< 1.0	8.6
101277-0003	Early Water (B/C)	< 0.2	0.02	< 0.0005	< 1.0	97	< 1.0	19	33	< 1.0	7.0
101277-0004	Early Water (Bot. C)	< 0.2	0.03	< 0.0005	< 1.0	109	< 1.0	74	29	< 1.0	2.8
101277-0005	Late Water (A/B)	< 0.2	0.07	< 0.0005	< 1.0	102	< 1.0	21	19	< 1.0	1.7
101277-0006	Late Water (B/C)	< 0.2	0.10	< 0.0005	< 1.0	101	< 1.0	24	19	< 1.0	1.0
101277-0007	Late Water (Bot. C)	< 0.2	0.05	< 0.0005	< 1.0	102	< 1.0	23	19	< 1.0	1.0
101277-0008	Final Water	< 0.2	0.04	< 0.0005	< 1.0	103	< 1.0	28	20	< 1.0	< 1.0

Only those analyses that show a noticeable change in the treated water and soil are described and discussed in the following section. These include major cations and anions, acidity and fecal coliform. Trace elements (e.g., Ni, Zn, Cu etc.) were at or near detection limit levels in the water (i.e., below EPA limits for primary drinking water) and these constituents exhibit only minor concentration variations in the soils after water percolation.

Summary of the Changes to Soil and Water Chemistry

Variations noted in the treated water after flow through the soil column

1. Moderate increase of fecal coliform (0-2 MPN/100 ml), strontium (0.096 to 2.3 mg/L), and sulfate (22 to 28 mg/L)
2. Minor increase of nickel, chloride and total organic carbon
3. Minor decrease of barium, magnesium, zinc, calcium and potassium

Changes to the A-horizon soil after water percolation

1. Moderate increase of chloride (6.4 to 26.3 mg/kg), sulfate (2.1 to 8.5 mg/kg), and pH (6.45 to 7.48)
2. Moderate decrease of fecal coliform (400 to 0 MPN/100 g), nitrate (51 to 0mg/kg), phosphate (5,083 to 4,683 mg/kg)
3. Minor decrease of potassium, calcium, magnesium, strontium, barium, chromium, copper, nickel, and zinc

Changes to the B-horizon soil after water percolation

1. Moderate increase of chloride (1.5 to 10.4 mg/kg), sulfate (0 to 5.6 mg/kg), nitrate (0 to 2 mg/kg) and total phosphate (3,802 to 5,168 mg/kg)
2. Minor decrease of potassium, calcium, strontium, barium, chromium, copper, nickel, and zinc

Changes to the C-horizon parent material after water percolation

1. Moderate increase of barium (76 to 93 mg/kg), calcium (6,667 to 7194 mg/kg), and pH (8.84 to 9.3)
2. Minor increase of chloride and total phosphate
3. Moderate decrease of sulfate (84 to 39 mg/kg) and magnesium (6,626 to 5,539 mg/kg)
4. Minor decrease of strontium, chromium, copper, nickel and zinc

Fecal Coliform

As indicated in the results of the column test experiment, all fecal coliform is contained in the A-horizon soil in relatively minor amounts and is a result of animal droppings. Sampling and analysis of waters after 6.6 and 41.2 gallons of percolation reveals most of the fecal coliform in water draining the A-horizon soil as expected. With time, the fecal coliform bacteria are eradicated by the chlorinated treated water, leaving no colonies in the soil after percolation of the 44 gallons. Only traces of fecal coliform remain in the water after percolation of all the water.

Soil Acidity

Sulfate and chloride can contribute to soil acidity by complexing with free hydrogen to form sulfuric and hydrochloric acid respectively. In the case of the Snowbowl soils, sulfate is being flushed out of the C-horizon parent material, but chloride is accumulating in all horizons. Measurements of pH, however, suggest that chloride is not contributing to acidity in these soils. In fact, the natural acidity of the soils is buffered to more neutral values by percolation of treated water through the column. Early water samples from the A/B and B/C intervals are acidic, but later samples from these intervals reveal more neutral values. This is probably the result of the water flushing out organic acids in the A- and B-horizons. Buffering of the A- and B-horizons by the treated water helps prevent the dissolution and loss of toxic metals (e.g., Ni, Cr) to the groundwater and also allows for adequate supply of essential micronutrients (e.g., Fe, Mn, Cu, Zn and Co). The low-level addition of chloride to the soils is not detrimental to plant growth because it is an essential micronutrient at these levels.[312]

Essential Nutrients

In addition to the soils cores collected for the column test, 14 surficial soils samples were collected from various locations within the Snowbowl SUP area. The nutrient content for these soils was analyzed, and the results are outlined in Table 3I-35.

Table 3I-35
Nutrient Analysis of Snowbowl Soils

Method Employed		EPA SW-846 9056		HACH 9056
LIMS ID	Sample ID	NO_2	NO_3	Phosphate
Units		mg/kg	mg/kg	mg/kg
101314-0001	SS-01	< 1.0	297	ND
101314-0002	SS-02	< 1.0	112	ND
101314-0003	SS-03	< 1.0	108	ND
101314-0004	SS-04	< 1.0	79	ND
101314-0005	SS-05	< 1.0	4	ND
101314-0006	SS-06	ND	52	ND
101314-0007	SS-07	ND	24	< 2.0
101314-0008	SS-08	<1.0	123	ND
101314-0009	SS-09	<1.0	176	< 2.0
101314-0010	SS-10	<1.0	33	4.5
101314-0011	SS-11	2.2	153	< 2.0
101314-0012	SS-12	<1.0	100	< 2.0
101314-0013	SS-13	ND	2	ND
101314-0014	SS-14	ND	70	ND

ND = Not Detected ay Specified Reporting Limit
Source: ESN Rocky Mountain, 2003

[312] Brady, 1990

Although the reclaimed water contains high levels of nitrate (approximately 20 mg/L), the soils column experiment shows leaching of nitrate from the soils by the treated wastewater. The soils column test, simulating many years of water loading, removes such processes as vegetative uptake and biological nitrogen fixation from the nutrient dynamics of the soils.

In the 14 soils analyzed, the nitrate content ranges from two to 297 mg/kg with a median concentration of 85 mg/kg. The results of the column test suggest that most of this nitrate would leach to groundwater early in the percolation of the treated wastewater. The nitrate would, however, be replenished to the soil through biological fixation of nitrogen from the atmosphere (i.e., conversion of N_2 to ammonia by soil microorganisms) and from deposition of nitrogen compounds from rain and snow.[313] Rates of nitrogen addition to soil by biological fixation and precipitation have been estimated at 15 and 5-8 kg/ha respectively.[314] Ammonia inputs would be oxidized to nitrate during the summer months by the nitrification process. The A-horizon soils promote nitrification because they are well aerated with an abundance of carbon and base-forming cations (e.g., Ca). The laboratory column experiment suggests that although some of the soluble nitrate would be leached in the spring by percolation of treated water from melting snow, it would be replenished during the summer months.

The manner in which these dynamics would be manifested in field conditions is subject to some uncertainty. The addition of reclaimed water had the effect of removing nitrogen from the soils in the accelerated laboratory experiment. However, the laboratory experiment does not consider the important processes of vegetative uptake, or nutrient cycling by soils microbes. Infiltration of reclaimed water snowmelt would occur over seasonal, annual, and decadal time scales. Under field conditions, the increased nitrogen loading via application of reclaimed water would be subject to uptake from vegetation and microbes, and could increase nitrogen availability in the soils.

A controlled experimental nitrogen fertilization study in the Loch Vale and Fraser experimental forests in northern Colorado from 1997-1999 offers some insight into potential soils response to increased nitrogen loading in a coniferous forest.[315] Two sites were treated with an ammonium nitrate (NH_4NO_3) fertilizer at a rate of 25 kg N/ha^{-1}/yr^{-1}.[316] The results of the study support the conclusion that generally, in nitrogen-limited forests, the available nitrogen pool does increase in response to fertilization. Initially, the increased nitrogen inputs were realized in the soil as organic nitrogen, and in the vegetation as increased foliar nitrogen levels.[317] This trend continued until the carbon-to-nitrogen (C:N) ratio of the forest soil reached a specific threshold, after which further nitrogen additions increased the rate of nitrogen mineralization by the soil and inorganic soil nitrogen levels.[318] Once this threshold was reached, increased rates of nitrogen

[313] Id.
[314] Id.
[315] Rueth, et al. 2003.
[316] Id.
[317] Id.
[318] Id.

cycling, and subsequent increased rates of nitrogen leaching from the soil were observed.[319]

It is likely that the response of the soils at the Snowbowl to increased nitrogen inputs would be similar. The increased nitrogen loading via application of the reclaimed wastewater would be likely to initially cause increases in organic and bio-available nitrogen within the soils, until reaching a similar threshold. Subsequently, increases in nitrogen mineralization and inorganic nitrogen would be expected, followed by increased leaching of excess nitrogen through the soils column.

A small amount of potassium was flushed from the soil (approximately 4.0 ppm) early in the percolation, but the overall potassium concentration of the soil is not affected by percolation of the treated water. In the column test, a substantial amount of phosphate leached from the A-horizon and re-precipitated in the B-horizon, but this phosphate was not detected in the early, late, or final water samples. The phosphate was therefore not being flushed from the soils by the treated water.

Total Dissolved Solids

Total Dissolved Solids (TDS) expresses the total concentration of solids remaining when a water sample is evaporated to dryness. The TDS of the treated water increases sharply in the early water sample from the bottom of the C-horizon and this probably reflects rapid flushing of sulfate from the parent material and strontium from soils to the treated water. The overall salinity or TDS of the treated water would not be expected to change noticeably via percolation of treated water through the soil profile.

Total Organic Carbon

Organic carbon creates reducing conditions in aquifers and surface waters, which can create biological oxygen demand (BOD) and hinder aquatic life habitat. The percolated treated water is receiving carbon mainly from the A-horizon, but the amount is inconsequential in relationship to the potential for change in redox conditions in groundwater and discharge areas.

Base-forming Cations

Calcium, which is an important cation for buffering acidity, uptake of nutrients for plants, and nitrification processes can contribute to water hardness depending on the amounts flushed to soil solution and groundwater. The calcium in this case is leached from both A- and B-horizons, but it is re-precipitated or adsorbed in the C-horizon. It would therefore not be flushed out of the soils to potentially contribute to the hardness of the groundwater. Strontium, on the other hand, would be flushed out of the A-horizon mainly, but minor increases in concentration in the treated water does not contribute to higher total dissolved solids.

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[319] Id.

Conclusions

The primary conclusions of the soil column experiment are:

1. Percolating treated wastewater through the soil profile would be unlikely to have a negative impact on either the soils or treated water.
2. Fecal coliform in the A-horizon soil could be reduced via the percolation of chlorinated wastewater. However, under field conditions, due to the chlorine's volatility and the aerating effect of distribution through snowmaking, the quantity of chlorine within the snowpack would be reduced, and the subsequent effect on soils bacteria would be less than observed in the laboratory.
3. Chloride and sulfate would be added to both the A- and B-horizon soils. A larger amount of sulfate could be lost from the C-horizon parent material to the groundwater. The low-level addition of these essential nutrients to the soils is generally beneficial to plant growth.
4. The acidity of the soil and parent material would be progressively buffered to more alkaline levels by percolation of the treated wastewater. The higher alkalinity would inhibit the leaching and mobilization of toxic metals to the groundwater, and would allow for an adequate supply of bio-available micronutrients (e.g. Fe, Mn, Cu, Zn, Co) to remain available for plant growth.
5. Nitrate, which is concentrated in A-horizon soil, would leach to the groundwater as the treated wastewater percolates through the column. The nitrate, however, would be replenished during the summer months by the addition of ammonia from the atmosphere through biological fixation and precipitation with subsequent oxidation of the ammonia to nitrate. However, under field conditions the nitrogen dynamics would differ. Due to vegetative and microbial assimilation, the increased nitrogen loading via the application of reclaimed water would initially increase organic nitrogen content and availability in the soils. After reaching a new dynamic equilibrium, however, further nitrogen inputs would be realized as increases in soils nitrogen mineralization, inorganic nitrogen, and leaching from the surface soils horizon. Other essential nutrients (i.e. potassium, phosphate, and sulfate) would not be removed from the A- and B horizon soils in substantial amounts.
6. Although the results of the column test show that salinity of the treated water (TDS) increases initially because of the addition of sulfate and strontium from the parent materials and soils, the overall salinity of the reclaimed water would be unlikely to change substantially through the soils column.
7. The total organic carbon content of the treated wastewater increased slightly, but would be unlikely to produce more reduced conditions in groundwater.

Although the results of the column test show that salinity of the treated water (TDS) increases initially because of the addition of sulfate and strontium from the parent materials and soils, the overall salinity of the reclaimed water would be unlikely to change substantially through the soils column.

The total organic carbon content of the treated wastewater increased slightly, but would be unlikely to produce more reduced conditions in groundwater.

Alternative 3

Under Alternative 3, input of additional water in the form of snowmaking would not occur, and changes in the soil chemistry regime are not anticipated. However, the proposed grading activities, utilizing heavy machinery, would cause soils compaction and loss of soil tilth. Loss of top soil and a decrease in soils organic matter associated with disturbances to the rooting zone could reduce the soils productivity.

CUMULATIVE EFFECTS

Scope of Analysis

Temporal Bounds

The temporal extent for the cumulative effects to soils and geological resources includes the lifespan of past, present, and reasonably foreseeable future projects outlined in Table C-1, located in Appendix C. This time period begins with initial construction of ski area trails and infrastructure in the late 1930s. The listed projects include various on-going activities, including private land development, whose timing is indefinite. For the purposes of this cumulative effects analysis, a period of 10 years from the date of this document has been considered.

Spatial Bounds

The spatial extent for the cumulative effects analysis is limited to the Snowbowl SUP area and adjacent restoration and development activities, as defined below.

Past, Present, and Reasonably Foreseeable Future Actions

Past, present and reasonably foreseeable future projects that, in addition to Snowbowl's exiting and proposed facilities, could cumulatively affect soils and geological resources include:

1. San Francisco Mountain Mineral Withdrawal
2. Bebbs Willow Restoration Project
3. Transwestern Lateral Pipeline Project
4. Inner Basin Water Pipeline Development and Maintenance
5. Private Land Development
6. Miscellaneous/ongoing Recreational Uses
7. Miscellaneous Facilities and trail construction within Snowbowl's SUP area

In addition, three indicators that were addressed in the direct and indirect analysis are repeated in this cumulative effects analysis to provide a conservative analytical reference point from which to compare cumulative basin water balance changes between pre-development conditions and proposed conditions within the SUP area. The analysis assumes that that undeveloped forested conditions exhibited 100 percent cover density. Actual conditions in a forest unaffected by human influences vary over time through cycles of fire, re-growth, and variation in vegetation species and density, and do not necessarily reflect a fully forested, mature vegetative cover.

These effects reflect the differences in the water balance between mature forest, and conditions where the fully forested baseline has been altered by the presence of vegetative clearing to construct existing ski trails and additional snowmaking water applications. The differences in the water balance between two different scenarios were analyzed:

1. Forest environment undisturbed by human activities, with mature trees, and a canopy with 100 percent cover density

2. Forest environment with the existing and proposed trail and snowmaking infrastructure present

San Francisco Mountain Mineral Withdrawal

The Peaks and surrounding area was withdrawn from availability for mineral entry in 2000. This action precludes individuals and entities from staking a mineral claim in preface to planned extraction activities within the withdrawn area. This action has and will provide added protection for soils and will decrease erosion potential by limiting potential ground disturbing activities associated with mining.

Bebbs Willow Restoration Project

In its Environmental Assessment,[320] the Forest Service anticipates that: "Soil condition will not be significantly affected by the thinning and tree removal aspect of the project." No heavy equipment will be used to harvest trees or pile slash. Most of the tree cutting will be accomplished by hand, producing no impact to the soil surface. Some soil cover and increase in coarse woody debris will result from the boles and limbs of the trees that remain after burning. By removing all trees over 60 acres and thinning trees less than six inches DBH over 288 acres, the grassland character of the prairie will be promoted. Ground cover composition will favor grasses and plant litter over needle cast from conifer trees.

Low-intensity fire can promote sediment production in the short term, before vegetation is re-established. In a natural fire disclimax, however, grassland vegetation re-establishes quickly. Over the long term, frequent, low-intensity fires that mimic the natural fire cycle can reduce sediment production by reducing the probability of a high-intensity fire and subsequent loss of soil organic matter and productivity.

Transwestern Lateral Pipeline

On-going operation and maintenance of the pipeline includes potential soil-disturbing activities, due to equipment and pipeline access. Many of these effects would be temporary during construction activities; however some activities could result in soil compaction and potential loss of productivity that would be cumulative in nature.

Inner Basin Water Pipeline Maintenance

Maintenance of the existing water pipeline operated by the City of Flagstaff within the Inner Basin on the northern slopes of the San Francisco Peaks could include pipeline repair and replacement activities that would involve soils disturbances from equipment

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[320] USDA Forest Service, 2001b.

access, as well as disturbance of shallow soil horizons during pipeline repairs. Many of these effects would be temporary during construction activities; however some activities could result in soils compaction and potential loss of productivity that would be cumulative in nature.

Private Land Development

Construction of houses and other buildings and infrastructure on private lands located within the lower Hart Prairie has and may continue to create localized soil disturbances associated with equipment access and construction activities. During construction, when vegetation is removed and soils are exposed, there is the potential for soil loss via erosion and sediment transport. The risk of soil loss typically decreases after landscaping and re-vegetation is complete. Many of these effects would be temporary during construction activities; however some activities could result in soils compaction and potential loss of productivity that would be cumulative in nature. Currently, there are approximately 13 summer homes developed in the lower Hart Prairie area. Additionally there are approximately four parcels of land which could potentially be developed as home sites.

Miscellaneous Recreational Uses

The San Francisco Peaks region is a popular destination for recreational activities, and recreational use is likely to increase in the future.[321] On-going recreational uses include hiking, camping, horse-back riding, bicycling, and off-road vehicle use. Scattered throughout the vicinity, recreational uses can cause loss of vegetative ground cover, soil compaction, localized erosion, and increased runoff. Although these effects are widely distributed in nature, and mitigated by Forest Service BMP's concerning recreational uses, they do represent cumulative impacts to soils resources.

Alternative 1 – No Action

Sediment-related cumulative effects are somewhat difficult to quantify. Existing conditions reflect changes in sediment yield, soils compaction and productivity that are reflective of distinct differences in land use, management, and cover between pre-Snowbowl development conditions and the modern ski area infrastructure, and are difficult to quantify accurately. Nonetheless, ground disturbance associated with past development/construction activities at the Snowbowl have cumulatively impacted soil resources in, and in the vicinity of, the SUP area from time to time. Historic and on-going operational and maintenance activities involve continuing use of existing roads, as well as some level of soils disturbance associated with routine construction and maintenance activities. Many of the effects are temporary during construction activities; however some activities would result in compacted soils and loss of organic matter, which would be ultimately permanent in nature, and therefore cumulative in effect beyond existing conditions.

Nonetheless, two activities noted above - San Francisco Mountain Mineral Withdrawal and Bebbs Willow Restoration – would cumulative benefit soil resources in the area.

[321] USDA Forest Service, 2001b.

Indicator:

Modeled Anticipated Changes In The Duration And Intensity Of Annual Snowmelt Compared To Historic Natural Variation

The cumulative changes in the water balance for Alternative 1 may be portrayed by comparing existing conditions to inferred pre-development conditions. The following tables display this comparison for average, dry, and wet-year climatic scenarios. Because precipitation inputs remain the same as those outlined in the previous sections, the tables show only the areas of trail construction, the projected watershed losses, recharge and the percent change versus pre-development conditions for each pertinent watershed.

Table 3I-36
Alternative 1 Average Year Water Balance Cumulative Effects

Watershed	Trail Construction (Acres)	Watershed Loss (AF)	Recharge (AF)	% Loss	Recharge Change (AF)[a]	Percent Change[a]
Hart Prairie	0.64	64.3	59.8	52%	0.3	0%
Humphreys	0.59	429.0	355.0	55%	0.2	0%
Lower Agassiz Ridge	13.50	368.3	199.8	65%	5.2	3%
Middle Agassiz Ridge	3.30	373.7	199.8	65%	1.3	1%
Snowbowl	123.10	940.8	850.5	53%	49.7	6%
Sunset	0.00	111.6	81.1	58%	0.0	0%
Upper Agassiz Ridge	0.00	432.8	239.7	64%	0.0	0%
Total	***145.0***	***2,720.4***	***1,985.6***	***58%***	***56.7***	***1%***

[a] Compared to pre-development conditions.
Source: Resource Engineering, Inc, 2003

Table 3I-37
Alternative 1 Dry Year Water Balance Cumulative Effects

Watershed	Trail Construction (Acres)	Watershed Loss (AF)	Recharge (AF)	% Loss	Recharge Change (AF)[a]	Percent Change[a]
Hart Prairie	0.64	49.5	9.9	97%	0.2	2%
Humphreys	0.59	295.6	27.0	92%	0.2	1%
Lower Agassiz Ridge	13.50	233.8	0.0	100%	0.0	0%
Middle Agassiz Ridge	3.30	236.0	0.0	100%	0.0	0%
Snowbowl	123.10	637.6	99.5	86%	52.0	109%
Sunset	0.00	74.8	4.5	94%	0.0	0%
Upper Agassiz Ridge	0.00	276.7	0.0	100%	0.0	0%
Total	***145.0***	***1,804.1***	***140.9***	***93%***	***52.4***	***16%***

[a] Compared to pre-development conditions.
Source: Resource Engineering, Inc, 2003

Table 3I-38
Alternative 1 Wet Year Water Balance Cumulative Effects

Watershed	Trail Construction (Acres)	Watershed Loss (AF)	Recharge (AF)	% Loss	Recharge Change (AF)[a]	Percent Change[a]
Hart Prairie	0.64	67.3	121.8	36%	0.2	0%
Humphreys	0.59	443.4	751.5	37%	0.2	0%
Lower Agassiz Ridge	13.50	383.6	482.3	44%	5.1	1%
Middle Agassiz Ridge	3.30	386.0	488.0	44%	1.3	0%
Snowbowl	123.10	976.2	1,754.0	36%	49.3	3%
Sunset	0.00	117.4	176.3	40%	0.0	0%
Upper Agassiz Ridge	0.00	445.7	579.1	43%	0.0	0%
Total	***145.00***	***2,819.8***	***4,353.0***	***39%***	***56.2***	***1%***

[a] Compared to pre-development conditions.
Source: Resource Engineering, Inc, 2003

A review of the water yield comparisons for the No Action alternative reveals that existing and Alternative 1 conditions reflect an approximate one percent change in annual recharge under average and wet-year conditions, and 16 percent in dry year conditions, when compared to pre-development conditions. For the primary Snowbowl watershed, which contains the bulk of the existing trail system, the Alternative 1 cumulative changes are six percent, 109 percent, and three percent, for the average, dry, and wet scenarios, respectively.

Alternative 2 – The Proposed Action

The Proposed Action would involve approximately 10.4 acres of permanent ground disturbance and 245.4 acres of temporary ground disturbance both within, and outside of, the SUP area.

The soils compaction and turnover associated with the proposed grading and trail construction activities would cause compaction of soils and loss of organic matter and tilth that would ultimately be permanent in nature, and therefore cumulative when considered with other past, present and reasonably foreseeable future actions, both within and outside of the SUP area. The estimates of increased sediment detachment would result in cumulative increases in sediment production of 178 tons for Alternative 2. Under Alternative 2, the anticipated decrease in detachment associated with decommissioning a section of existing access road would be 14.3 tons. The new road segment to serve the snowmaking water impoundment access road in Alternative 2 would represent an increase of 25.5 tons of sediment detachment. The net result would be an increase in road detachment of 11.2 tons that contributes six percent of the anticipated cumulative increase of 178 tons. These quantities represent detachment, not transport, but highlight the importance of implementation and operational practices designed to manage water drainage, facilitate re-vegetation, and minimize sediment transport.

When considered with the Transwestern Lateral Pipeline construction, Inner Basin water pipeline maintenance, private land development and miscellaneous recreational uses, the Proposed Action represents a cumulative effect to soil resources in the analysis area.

Indicator:

Modeled Anticipated Changes In The Duration And Intensity Of Annual Snowmelt Compared To Historic Natural Variation

The snowmaking and trail construction of the Proposed Action would result in cumulative water balance effects, for average, dry, and wet-year climates as indicated in the following tables.

Table 3I-39
Alternative 2 - Average Year Water Balance Cumulative Effects

Watershed	Trail Construction (Acres)	Snowmaking (AF)	Watershed Loss (AF)	Recharge (AF)	% Loss	Recharge Change (AF)[a]	Percent Change[a]
Hart Prairie	3.7	39.9	81.3	82.6	50%	23.1	39%
Humphreys	9.6	50.4	451.8	382.5	54%	27.8	8%
Lower Agassiz Ridge	7.2	22.5	377.5	213.2	64%	18.5	10%
Middle Agassiz Ridge	1.6	6.9	376.7	203.7	65%	5.1	3%
Snowbowl	54.0	234.0	1,043.0	982.3	51%	181.5	23%
Sunset	0.2	9.8	116.7	85.7	58%	4.7	6%
Upper Agassiz Ridge	0.0	0.5	433.0	239.9	64%	0.3	0%
Total	***76.3***	***364.0***	***2,880.1***	***2,189.9***	***57%***	***261.0***	***12%***

[a] Compared to pre-development conditions.
Source: Resource Engineering, Inc, 2003

Table 3I-40
Alternative 2 - Dry Year Water Balance Cumulative Effects

Watershed	Trail Construction (Acres)	Snowmaking (AF)	Watershed Loss (AF)	Recharge (AF)	% Loss	Recharge Change (AF)[a]	Percent Change[a]
Hart Prairie	3.7	53.3	90.3	14.1	87%	4.4	46%
Humphreys	9.6	67.3	358.8	31.1	92%	4.3	16%
Lower Agassiz Ridge	7.2	30.1	263.9	0.0	100%	0.0	0%
Middle Agassiz Ridge	1.6	9.2	245.2	0.0	100%	0.0	0%
Snowbowl	54.0	312.4	927.2	122.4	88%	74.8	157%
Sunset	0.2	13.0	87.8	4.6	95%	0.1	2%
Upper Agassiz Ridge	0.0	0.7	277.4	0.0	100%	0.0	0%
Total	***76.3***	***486.0***	***2,250.7***	***172.1***	***93%***	***83.6***	***32%***

[a] Compared to pre-development conditions.
Source: Resource Engineering, Inc, 2003

Table 3I-41
Alternative 2 - Wet Year Water Balance Cumulative Effects

Watershed	Trail Construction (Acres)	Snowmaking (AF)	Watershed Loss (AF)	Recharge (AF)	% Loss	Recharge Change (AF)[a]	Percent Change[a]
Hart Prairie	3.7	26.6	82.4	133.3	38%	11.7	10%
Humphreys	9.6	33.6	461.3	767.2	38%	16.0	2%
Lower Agassiz Ridge	7.2	15.0	398.7	482.3	45%	5.1	1%
Middle Agassiz Ridge	1.6	4.6	384.6	494.1	44%	7.3	1%
Snowbowl	54.0	156.2	1,090.1	1,796.3	38%	91.6	5%
Sunset	0.2	6.5	121.6	178.7	40%	2.4	1%
Upper Agassiz Ridge	0.0	0.4	446.0	579.3	43%	0.1	0%
Total	***76.3***	***243.0***	***2,984.7***	***4,431.1***	***40%***	***134.2***	***3%***

[a] Compared to pre-development conditions.
Source: Resource Engineering, Inc, 2003

A review of the water yield comparisons for the Proposed Action reveals that Alternative 2 conditions reflect an approximate 12 percent change in annual recharge under average conditions, 16 percent in dry year conditions, and three percent in wet year conditions, when compared to pre-development conditions. For the primary Snowbowl watershed, which would experience most of the proposed snowmaking and trail construction, cumulative changes associated with the Proposed Action are 23 percent, 157 percent, and five percent, for the average, dry, and wet scenarios, respectively.

The primary potential cumulative effect of the changes in the water balance, paired with changes in soils properties caused by the proposed trail construction and trail grading, would be enhancement of the potential for concentrated surface flows. In addition, field review reveals that in existing areas of heavily graded terrain, surface overland flow does occur during the snowmelt season. The increases in water input due to snowmaking would be likely to enhance the potential for further rilling and incisement of flow channels, and transport of surface sediments on graded terrain. As discussed in the Direct and Indirect Effects section, the risk of surface flow and rilling would be minimal for ungraded and flush-cut terrain. For graded terrain, implementation of adequately spaced waterbars to route and dissipate surface flows, coupled with successful re-vegetation, would mitigate the risk of surface rilling in areas where topographic constraints do not tend to channelize and concentrate flows. In areas where topographic lows tend to concentrate any occurring surface flows, the risk of rilling and sedimentation would be moderate to high for graded terrain.

Indicator:

Analysis Of Potential Changes To Soil Chemistry Due To Anticipated Increases In Soil Moisture Consistency And Nutrient Loading

Soil Acidity

The laboratory column experiment suggests that application of the reclaimed water product via snowmaking would increase the alkalinity of the receiving soils, thereby resulting in an increased buffering capacity. Mixed and diluted by natural precipitation, this buffering effect would be reduced. However, over time, the cumulative trend would be towards slightly more alkaline soils over natural conditions.

Essential Nutrients

A review of the existing nitrogen content for the soils within the SUP area reveals nominal levels of nitrate. The laboratory experiment, conducted on an accelerated timescale when compared to natural processes, suggests that nitrate would be leached from the surface soils horizon by the reclaimed water. However, under field conditions the nitrogen dynamics would differ. Due to vegetative and microbial assimilation, the increased nitrogen loading via application of reclaimed water would initially increase organic and bio-available nitrogen content in the soils. Once a critical carbon-to-nitrogen ratio is reached, subsequent increases in nitrogen mineralization and inorganic soils nitrogen content would be realized. Subsequently, excess nitrogen would begin to leach from the soils column to groundwater. Nonetheless, these effects would be limited in spatial extent to the receiving soils within Snowbowl's ski trail corridors. Effects to the native, undisturbed soils under the forest canopy would be minimal. Increased nutrient loading could increase the biomass of grasses on existing trails, and enhance the re-vegetation process on new or recently disturbed ski trails, improving the resultant cover density for the native grass species that would be utilized for re-seeding and re-vegetation.

Alternative 3

Alternative three would involve approximately 1.7 acres of permanent ground disturbance and 131.4 acres of temporary ground disturbance within the SUP area. The soils compaction and turnover associated with Alternative 3 grading and trail construction activities (after re-vegetation) would cause compaction of soils and loss of organic matter and tilth that would ultimately be permanent in nature, and therefore cumulative when considered with other past, present and reasonably foreseeable future actions, both within and outside of the SUP area. The estimates of increased sediment detachment associated with Alternative 3 would result in cumulative increases in sediment production of 158 tons. The primary difference between alternatives 2 and 3 is the lack of the proposed snowmaking water impoundment and the associated access road. The new road spur would not be present in Alternative 3, nor would de-commissioning of a portion of the existing access road occur. Thus, no net changes in the road sediment detachment would be anticipated under Alternative 3. These quantities represent detachment, not transport, but highlight the importance of implementation and operational practices designed to manage water drainage, facilitate re-vegetation, and minimize sediment transport.

When considered with the Transwestern Lateral Pipeline construction, Inner Basin water pipeline maintenance, private land development and miscellaneous recreational uses, Alternative 3 represents a cumulative effect to soil resources in the analysis area, although it is less than the Proposed Action.

Indicator:

Modeled Anticipated Changes In The Duration And Intensity Of Annual Snowmelt Compared To Historic Natural Variation

Although no snowmaking is proposed under Alternative 3, clearing of vegetation and land cover changes resulting from trail construction would alter the water balance in a cumulative manner. The effects are outlined in the following tables:

Table 3I-42
Alternative 3 - Average Year Water Balance Cumulative Effects

Watershed	Trail Construction (Acres)	Snowmaking (AF)	Watershed Loss (AF)	Recharge (AF)	% Loss	Recharge Change (AF)[a]	Percent Change[a]
Hart Prairie	1.6	0.0	64.3	59.8	52%	0.3	0%
Humphreys	2.0	0.0	428.2	355.8	55%	1.0	0%
Lower Agassiz Ridge	7.7	0.0	365.3	202.8	64%	8.2	4%
Middle Agassiz Ridge	1.6	0.0	373.1	200.4	65%	1.9	1%
Snowbowl	54.0	0.0	919.0	872.3	51%	71.6	8%
Sunset	0.2	0.0	111.6	81.2	58%	0.1	0%
Upper Agassiz Ridge	0.0	0.0	432.8	239.7	64%	0.0	0%
Total	***67.1***	***0.0***	***2,694.1***	***2,011.9***	***57%***	***83.0***	***2%***

[a] Compared to pre-development conditions.
Source: Resource Engineering, Inc, 2003

Table 3I-43
Alternative 3 - Dry Year Water Balance Cumulative Effects

Watershed	Trail Construction (Acres)	Snowmaking (AF)	Watershed Loss (AF)	Recharge (AF)	% Loss	Recharge Change (AF)[a]	Percent Change[a]
Hart Prairie	1.6	0.0	49.5	9.9	97%	0.2	2%
Humphreys	2.0	0.0	294.8	27.9	91%	1.1	4%
Lower Agassiz Ridge	7.7	0.0	233.8	0.0	100%	0.0	0%
Middle Agassiz Ridge	1.6	0.0	236.0	0.0	100%	0.0	0%
Snowbowl	54.0	0.0	614.8	122.4	83%	74.8	61%
Sunset	0.2	0.0	74.7	4.6	94%	0.1	2%
Upper Agassiz Ridge	0.0	0.0	276.7	0.0	100%	0.0	0%
Total	***67.1***	***0.0***	***1,780.3***	***164.7***	***92%***	***76.2***	***10%***

[a] Compared to pre-development conditions.
Source: Resource Engineering, Inc, 2003

Table 3I-44
Alternative 3 - Wet Year Water Balance Cumulative Effects

Watershed	Trail Construction (Acres)	Snowmaking (AF)	Watershed Loss (AF)	Recharge (AF)	% Loss	Recharge Change (AF)[a]	Percent Change[a]
Hart Prairie	1.6	0.0	67.3	121.8	36%	0.2	0%
Humphreys	2.0	0.0	442.6	752.3	37%	1.0	0%
Lower Agassiz Ridge	7.7	0.0	380.7	485.2	44%	8.1	2%
Middle Agassiz Ridge	1.6	0.0	385.4	488.7	44%	1.9	0%
Snowbowl	54.0	0.0	954.6	1,775.6	35%	70.9	4%
Sunset	0.2	0.0	117.4	176.4	40%	0.1	0%
Upper Agassiz Ridge	0.0	0.0	445.7	579.1	43%	0.0	0%
Total	***67.1***	***0.0***	***2,793.8***	***4,379.1***	***39%***	***82.2***	***1%***

[a] Compared to pre-development conditions.
Source: Resource Engineering, Inc, 2003

A review of the water yield comparisons for Alternative 3 reveals an approximate two percent change in annual recharge under average conditions, 10 percent in dry year conditions, and one percent in wet year conditions, when compared to pre-development conditions. For the primary Snowbowl watershed, which would experience most of the proposed snowmaking and trail construction, the Alternative 3 cumulative changes are eight percent, 61 percent, and four percent, for the average, dry, and wet scenarios, respectively.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Because pedogenesis (development or generation of new soils) is a process that occurs over the course of decades and centuries, the effects of soils compaction, loss of organic matter and tilth, and soils loss via increased detachment and transport may be considered an irreversible commitment of resources. Careful implementation of the mitigation measures outlined in Chapter 2 would reduce the overall magnitude of these anticipated losses.

3J. VEGETATION

SCOPE OF THE ANALYSIS

The analysis area for vegetation includes the SUP area, Snowbowl Road, and the proposed reclaimed water pipeline alignment between the City of Flagstaff and the SUP. Indirect effects to vegetation are considered in the areas adjacent to the SUP, Snowbowl Road, and the pipeline alignment. This includes undeveloped portions of the CNF, the Kachina Peaks Wilderness Area, and areas downslope of the SUP area (primarily Hart Prairie). The extent to which adjacent areas are included in the overall analysis area varies with each specific issue analyzed. Vegetation communities in the analysis area are primarily montane conifer forests and grasslands.

EXISTING CONDITIONS

PLANT COMMUNITIES

The SUP is located on the southwestern slopes of the San Francisco Peaks, at elevations ranging from approximately 9,150 feet to 12,040 feet elevation. The predominant biotic community within the Snowbowl SUP is Rocky Mountain Subalpine Conifer Forest and Woodland, within the Engelmann Spruce-Subalpine Fir Series (Table 3J-1).[322] Subalpine or corkbark fir (Abies lasiocarpa) is dominant in this community, followed by Engelmann spruce (Picea engelmannii), and in places stands of aspen (Populus tremuloides) with a spruce-fir understory.

Approximately 21.7 acres of the extreme southwest corner of the SUP is mapped as Mixed Conifer Forest, within the Rocky Mountain Montane Conifer Forest biotic community. These areas support Douglas-fir (Pseudotsuga menziesii), limber pine (Pinus flexilis), and aspen, but less than five percent subalpine or corkbark fir and few Engelmann spruce.

Table 3J-1
Approximate Area of Subalpine Grassland, Spruce-fir Forest, and Alpine Tundra in the SUP and on the San Francisco Peaks[323]

Type	SUP[324]	San Francisco Peaks
Subalpine Grassland	±37 acres	1,027 acres
Spruce-fir Forest	±547 acres	7,170 acres
Alpine Tundra	±20 acres	±1,600 acres

[322] Brown, 1994.
[323] Areas outside SUP. Estimated based in part on descriptions in Brown (1994) and Northland Research (2003).
[324] Excludes developed ski trails (138.6 acres) and other developed areas such as roads, guest service facilities, parking, buildings, etc. (±20 acres). The ±17 acres of Subalpine Grassland disturbed in Hart Prairie is still classified as such.

The upper portion of Hart Prairie, in the northwest corner of the SUP, is best described as Rocky Mountain Subalpine Grassland. This area is dominated by grasses and forbs, including fescue (Festuca spp.), squirrel-tail (Sitanion hystrix), orchard grass (Dactylis glomerata), wheat-grass (Agropyron trachycaulum), deers-ears (Swertia sp.), silverleaf cinquefoil (Potentilla anserina), red-root eriogonum (Eriogonum racemosum), Rocky Mountain iris (Iris missouriensis), lupine (lupinus sp.), Indian paintbrush (Castilleja sp.), and towering delphinium (Delphinium tenuisectum).

The extreme eastern extent of the SUP area, on the western slope of Agassiz Peak and above the top terminal of the Agassiz Chairlift, supports Alpine Tundra. Tundra plants are predominantly forbs, with islands of gnarled krummholz of bristlecone pine (Pinus aristata), corkbark fir, and Engelmann spruce.[325] The upper portion of Snowbowl Road winds through aspen, spruce-fir, and mixed conifer forest. The remainder of Snowbowl Road below approximately 8,000 feet in elevation and the remainder of the proposed reclaimed water pipeline alignment are located in ponderosa pine forest.

The Kachina Peaks Wilderness area adjacent to the SUP supports high elevation mixed conifer forest, spruce-fir forest, and alpine tundra. The upper portion of Hart Prairie (above approximately 8,500 feet) represents subalpine grassland.[326] Lower portions of Hart Prairie represent montane meadow grassland, transitioning to plains grassland in the Fort Valley area.

THREATENED, ENDANGERED, AND SENSITIVE SPECIES

Section 7 of the Endangered Species Act of 1973 (ESA), as amended 1978, 1979, 1982, and 1988 declares that "…all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purposes of this Act."[327] Section 7 directs Federal agencies to ensure that actions authorized, funded, or carried out by them are not likely to jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of their critical habitats.[328] Federal agencies also must consult with U.S. Fish and Wildlife Service whenever an action authorized by the agency is likely to affect a species listed as threatened or endangered or to affect its critical habitat. ESA mandates conference with the Secretary of the Interior whenever an action is likely to jeopardize the continued existence of any species proposed for listing as threatened or endangered, or whenever an action might result in destruction or adverse modification of critical habitat proposed for listing.[329]

Forest Service Sensitive species are defined as "those plant and animal species identified by a Regional Forester for which population viability is a concern, as evidenced by: a) significant current or predicted downward trends in population numbers or density, or b) significant current or predicted downward trends in habitat capability that would reduce a

[325] Brown, 1994
[326] Brown, 1994
[327] 16 U.S.C. 1531 et seq.
[328] 16 U.S.C. 1536 et sq.
[329] 16 U.S.C. 1536(a) 4

species' existing distribution".[330] It is the policy of the Forest Service regarding Sensitive Species to 1) assist States in achieving their goals for conservation of endemic species, 2) as part of the National Environmental Policy Act process, review programs and activities, through a biological evaluation, to determine their potential effect on sensitive species, 3) avoid or minimize impacts to species whose viability has been identified as a concern, 4) if impacts cannot be avoided, analyze the significance of potential adverse effects on the population or its habitat within the area of concern and on the species as a whole (the Line Officer, with project approval authority, makes the decision to allow or disallow impacts, but the decision must not result in loss of species viability or create significant trends toward Federal listing), and 5) establish management objectives in cooperation with the State when projects on National Forest system lands may have a significant effect on sensitive species population numbers or distributions. Establish objectives for Federal candidate species, in cooperation with the U.S. Fish and Wildlife Service and Arizona State.[331]

A Biological Assessment/Biological Evaluation (BA/BE) was prepared for this project and will be submitted to the U.S. Fish and Wildlife Service for concurrence with the determination of effects to T and E species. The Forest Service will also review and approve the BE according to its determinations for Forest Service Sensitive species. The Threatened, Endangered, and Sensitive Species (TES) List for the Mormon Lake and Peaks Ranger District was reviewed by the Forest botanist, and a TES list was created for this project in July 2002. One federally-listed threatened plant species occurs in the analysis area: San Francisco Peaks groundsel (Senecio franciscanus). Critical habitat designated for this plant includes the extreme eastern portion of the SUP area, above the top terminal of the Agassiz Chairlift. Two Forest Service Sensitive plant species occur within the analysis area: bearded gentian (Gentiana barbellata) and Rusby's milkvetch (Astragalus rusbyi). Potential habitat exists within the analysis area for the Forest Service Sensitive crenulate moonwort (Botrychium crenulatum). This species has not been recorded within the SUP area. There are no other listed, proposed, or candidate species or their habitat in the analysis area. There is no other designated or proposed critical habitat either. Sensitive species that have been eliminated from further analysis due to lack of habitat are listed in Table 3J-2.

Table 3J-2
Forest Service Sensitive Plant Species Eliminated from Further Analysis

Common Name	Scientific Name
Arizona Bugbane	Cimicifuga arizonica
Cliff Fleabane	Erigeron saxatilis
Flagstaff Beardtongue	Penstemon nudiflorus
Flagstaff Pennyroyal	Hedeoma diffusum
Sunset Crater Beardtongue	Penstemon clutei
Disturbed Rabbitbrush	Chrysothamnus molestus

[330] FSM 2670.5(19)
[331] FSM 2670.32

San Francisco Peaks Groundsel (Senecio franciscanus) - Threatened

San Francisco groundsel is endemic to the San Francisco Peaks and grows on gravelly, sandy loams of talus in alpine fellfield above 10,900 feet in elevation.[332] It is generally found on southeast exposures with 20 percent slope and reproduces mainly via rhizomes, although sexual reproduction also occurs. Flowering is from August to early September, fruits mature in mid-September, and the plant becomes winter-dormant in early October.[333] Critical habitat has been designated and includes a portion of the eastern-most extent of the SUP, above the Agassiz Chairlift top terminal.[334]

Plant populations were originally mapped and described in 1978 and 1980 and have been periodically monitored since that time. Surveys of proposed disturbance areas were completed in 1993 and 2002.[335] Approximately 10 individuals of San Francisco Peaks groundsel were found in an approximate one foot by one inch patch. These occur immediately adjacent to the unnamed catwalk above the Upper Bowl. They have been rocked off from the rest of the catwalk with small boulders. They occur approximately half way between the old lift terminal and the switchback. Consultation with US Fish and Wildlife Service on the effects of recreation is ongoing. The Recovery Plan for San Francisco Peaks Groundsel is currently being updated.

Bearded Gentian (Gentiana barbellata) - Sensitive

Bearded gentian grows on moderately wet rocky slopes, meadows, and open woods in Wyoming, Utah, New Mexico, and northern Arizona. In Arizona, it is known only in the San Francisco Peaks at 8,700 to 12,000 feet.[336]

Surveys were conducted in 2002 for the proposed project elements within the SUP. Six individuals of bearded gentian were found, two on *Lower Bowl* (trail #29) and four on *Lower Sundance* (trail #30).[337] The CNF also conducted surveys over a two-week period on and around the high peaks and ridges east of the SUP area. These surveys covered an estimated 30 percent of potentially suitable habitat identified on aerial photos.[338]

Rusby's Milkvetch (Astragalus rusbyi) - Sensitive

Rusby's milkvetch is a slender perennial that grows on dry basaltic soils in openings or meadows in Ponderosa Pine forest and at the edges of thickets and aspen groves. It occurs in the Flagstaff area and the lower slopes of the San Francisco Peaks at 7,000 to 8,000 feet, and down into Oak Creek Canyon.[339] It is known only from northern Arizona at 5,400 feet to 9,000 feet. This species is fire-adapted and has a high tolerance for disturbance.

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[332] Arizona Rare Plant Committee, 2001 and USFWS 1998

[333] USDI 1983

[334] USDI 1983

[335] Phillips, 1993 and Northland, 2003

[336] Northland Research, 2003 and Kearny and Peebles, 1960 and McDougall, 1973

[337] Northland Research, 2003

[338] CNF Zone Botanist personal communication, 2003

[339] Arizona Rare Plant Committee, 2001

Suitable habitat for Rusby's milkvetch occurs along Snowbowl Road between the SUP and U.S. Highway 180 (US 180). During surveys in 2003, it was found along two distinct segments of the road; the first was within 1-2 miles of US 180, and the second was within about 4-5 miles of US 180. Plants were found mainly in the drainage area next to the road, although some occurred higher up on the hill or cut slope. An estimated total of 120 plants were found along these two segments of Snowbowl Road.

Crenulate Moonwort (Botrychium crenulatum) – Sensitive

The crenulate moonwort is a tiny grape-fern that was described as a separate species in 1981 from the more widespread moonwort (*Bothrychium lunaria*). This plant was first collected in 1884 on Mt. Agassiz at an elevation of 11,000 feet. The 1884 collection has been annotated as *B. crenulatum*. Several more recent collections of *B. lunaria* and other species of *Botrychium* have been made on the Peaks. The more widespread *B. lunaria* has been found on Fremont, the southwest side of Agassiz at 11,700 feet under bristlecone pine, and in the Inner Basin.[340] Habitat for B. crenulatum in California is described as "drier places of damp meadows, boggy areas …".[341]

Surveys were conducted in 1993 for the catwalk between the Agassiz Chairlift mid-station and *Ridge* (trail #26) and for the widening of *Logjam* (trail #25).[342] Additional surveys were conducted in 2002 for the proposed project elements within the SUP.[343] No individuals of crenulate moonwort or any member of this genus were observed during surveys.

NOXIOUS WEEDS

Noxious and invasive weeds are defined as "those plant species designated as noxious and invasive weeds by the Secretary of Agriculture or by the responsible State Official. Noxious and invasive weeds generally possess one or more of the following characteristics; aggressive and difficult to manage, poisonous or toxic, parasitic, a carrier or host of serious insects or disease, and being non-native, new to, or not common to the United States or parts thereof."[344]

Six species included on the Coconino, Kaibab, and Prescott national forests Invasive Plant Species List of 2001 have been documented within the analysis area (Table 3J-3). The plants on this list have weedy characteristics that include the ability to rapidly colonize a variety of environments and geographic locations, the ability to dominate a plant community or establish a monoculture in severely disturbed areas, become a permanent member of the native plant community or colonize undisturbed native plant communities. Three weedy species have been documented in the SUP: dalmation toadflax (Linaria dalmatica), mullein (Verbascum thapsus), and houndstongue (Cynoglossum officinale). All of these plants were found in disturbed soils around the base of the ski area, including ski trails, roads, buildings, lifts, parking lots, and heavily

[340] Phillips, 1993 and Northland Research, 2003
[341] Phillips, 1993
[342] Phillips, 1993
[343] Northland Research, 2003
[344] FSM 2080

used pedestrian areas such as Hart Prairie. None of these species were found spreading into undisturbed, unfragmented forest habitat, and no noxious weeds were found above 9,800 feet in elevation.[345] In addition to these species, the following weedy species were also documented along Snowbowl Road and the reclaimed water pipeline alignment: bull thistle (Cirsium vulgare), musk thistle (Carduus nutans), and kochia (Kochia scoparia). The latter three species were found in relatively few distinct locations, while dalmation toadflax and mullein are fairly common along the length of Snowbowl Road and the length of the reclaimed water pipeline alignment.[346]

Table 3J-3
Noxious Plant Species Documented within the Analysis Area and their Distribution

Common Name	Scientific Name	Distribution	Area Occupied
Dalmation toadflax	Linaria dalmatica	SUP	0.04 ac. (21 locations)
		Snowbowl Rd/Pipeline	Throughout
Mullein	Verbascum thapsus	SUP	0.003 ac. (17 locations)
		Snowbowl Rd/Pipeline	Throughout
Houndstongue	Cynoglossum officinale	SUP	0.001 ac. (3 locations)
		Snowbowl Rd/Pipeline	None
Bull thistle	Cirsium vulgare	SUP	None
		Snowbowl Rd/Pipeline	Two plants (1 location)
Musk thistle	Carduus nutans	SUP	None
		Snowbowl Rd/Pipeline	Six plants (1 location)
Kochia	Kochia scoparia	SUP	None
		Snowbowl Rd/Pipeline	30 sq. ft. (1 location)

ENVIRONMENTAL CONSEQUENCES

SUMMARY OF ENVIRONMENTAL CONSEQUENCES AND CONCLUSIONS

Major conclusions and determinations of this Vegetation analysis are summarized below. A more detailed analysis of the direct and indirect environmental consequences – from which this summary was derived – follows.

Alternative 1 – No Action

In summary, Alternative 1 would result in no changes to existing ski area operations or to forest management practices within the SUP area. As a result, the CNF would continue treatment of spruce bark beetle infected trees. This type of treatment would not address overall stand health.

Alternative 2 – The Proposed Action

The Proposed Action would affect approximately one percent of the total spruce-fir forest cover on the San Francisco Peaks and approximately 14 percent of the spruce-fir forest within the SUP area. It would also allow for the treatment of 48.4 acres of spruce-fir forest to address a localized spruce bark beetle outbreak. This would result in an

[345] Northland Research, 2003

[346] Northland Research, 2003 and USDA, 2003

improvement to stand health overall. This alternative would result in the temporary ground disturbance along 14 miles of proposed reclaimed water pipeline right-of-way, and the associated removal of 22 aspen trees and 134 pine trees.

Alternative 2 would permanently affect 0.3 percent, and temporarily affect 1.7 percent of subalpine grassland on the San Francisco Peaks. It would result in permanent losses of 7.3 percent. and temporary effects to 49.2 percent of the subalpine grassland within the SUP area, most of which has been previously disturbed.

The Proposed Action would result in disturbance within mapped critical habitat for the threatened San Francisco Peaks groundsel, but would not affect actual habitat or plants. It also may impact individuals of the bearded gentian and the Rusby's milkvetch, but it is not likely to result in a trend toward Federal listing or loss of viability. Alternative 2 would have no impact on the crenulate moonwort.

Lastly, the addition of snowmaking to operations at Snowbowl would result in an overall increase in moisture and nutrients and may change plant species composition within the SUP area. Proposed snowmaking is likely to add 31.1 lbs/acre/yr of nitrogen over historic natural deposition. This may increase the dominance of early successional or weedy plant species. In turn, this may reduce overall plant diversity in some portions of the SUP; however, this effect would be restricted to developed ski trails and therefore localized.

Alternative 3

Because Alternative 3 does not propose snowmaking or snowplay, the effects to vegetation resources would be fewer than those disclosed under Alternative 2. With respect to trail clearing, 64.4 acres of permanent overstory clearing would occur in spruce-fir forest (compared to 76.3 acres under Alternative 2). Additionally, Alternative 3 includes the treatment of 48.4 acres of spruce-fir to address a localized outbreak of spruce bark beetle. As stated previously, this would result in an improvement to stand health overall. There would be no removal of trees for construction of a reclaimed water pipeline under this alternative.

Because snowplay facilities are not proposed under Alternative 3, the effects to subalpine grasslands would be greatly reduced as compared to those disclosed in the Proposed Action. This alternative would result in the permanent loss of 0.01 percent, and the temporary disturbance of 1.7 percent, of the subalpine grassland on the San Francisco Peaks.

Alternative 3 would result in disturbance within mapped critical habitat for the threatened San Francisco Peaks groundsel, but would not affect actual habitat or plants. It also may impact individuals of the bearded gentian. Because no pipeline from Flagstaff is proposed, Alternative 2 would have no impact on the Rusby's milkvetch. As with the Proposed Action, this alternative would have no effect on the crenulate moonwort.

DETAILED ANALYSIS OF DIRECT AND INDIRECT EFFECTS

Impacts to T, E and S plant species, and regionally important plant communities

Issue:

Plant communities within the SUP area may be altered as a result of the proposed projects.

Indicator:

Acres Of High-Elevation Forest Type on the San Francisco Peaks, Within The SUP, and Potentially Affected by the Proposed Action

Alternative 1 – No Action

Under Alternative 1, there would be no overstory tree removal in the analysis area; therefore, the total acreage of mixed conifer and spruce-fir forest on the San Francisco Peaks would not change. The CNF would continue treatment of spruce-fir stands in the SUP infected by spruce bark beetles. These treatments would be limited to specific infected trees, which would be felled and de-barked in-place. These treatments would likely also include the use of an anti-aggregation pheromone to attempt to curtail the spread of bark beetles, but would not address overall stand condition. Past vegetation manipulation activities within the SUP area are further discussed in the Cumulative Effects section.

Alternative 2 – The Proposed Action

This alternative would result in 76.3 acres of permanent overstory vegetation removal within spruce-fir forest in the SUP. This represents about one percent of the total spruce-fir forest cover on the San Francisco Peaks and about 14 percent of the remaining spruce-fir forest in the SUP. Cutting of new ski trails would expose previously interior trees to newly-cleared edges. Some additional (secondary) mortality of trees from wind blowdown along these cleared edges would likely occur. There would be no overstory vegetation removal within the identified mixed conifer forest. Up to 22 aspen trees and 134 pine trees would be removed over 14 miles of right-of-way to allow construction of the reclaimed water pipeline.

In addition to tree removal associated with new ski trails, the Proposed Action would allow treatment of 48.4 acres of spruce-fir forest within the Agassiz and Sunset pods to create gladed skiing terrain and to address a localized spruce bark beetle outbreak. This treatment would consist of removal of up to 20 percent of standing trees and removal of dead and down material. Tree removal would target pockets of overmature and beetle-infested trees. Removal of trees and dead and down materials would result in a more open stand with a higher diversity of size classes and greater proportion of younger vegetation structural stages. Compared with existing treatment that would occur under the No Action alternative, treatment of entire stands would be more effective in addressing the localized spruce bark beetle outbreak. It would reduce the probability of complete loss of this stand and inhibit the potential infestation of other stands in the SUP and in the adjacent Kachina Peaks Wilderness area.

Noxious weeds have been found in the analysis areas, including the lower portion of the SUP and areas immediately adjacent to Snowbowl Road. The likelihood or risk of noxious weed spread is rated as moderate. Project activities under Alternative 2 may result in additional areas becoming infested with invasive weed species even when preventative management actions are followed. However, mitigation measures are incorporated in Chapter 2 for both action alternatives to reduce the likelihood of invasion and spread.

Alternative 3

The effects of this alternative are similar to the Proposed Action, but would result in 12 fewer acres of impact to spruce-fir forest. This alternative would result in 64.4 acres of permanent overstory vegetation removal within spruce-fir forest. This represents less than one percent of the total spruce-fir forest cover on the San Francisco Peaks and about 12 percent of the remaining spruce-fir forest in the SUP. The reduction in impact to this forest type under this alternative is due to the elimination of the snowplay area and snowmaking water impoundment, and fewer acres of developed ski trails. Secondary mortality to trees from wind throw along newly-exposed ski trail edges would be similar to that under the Proposed Action. No trees would be removed along Snowbowl Road or the remainder of the reclaimed water pipeline right-of-way proposed under Alternative 1.

This alternative would also allow treatment of 48.4 acres of spruce-fir forest within Agassiz and Sunset pods to create gladed skiing and address a localized spruce bark beetle outbreak and the effects would be the same as those described under the Proposed Action.

Indicator:

Potential Impacts to Montane Grasslands Within the SUP as a Proportion of Total Grasslands on the San Francisco Peaks

Alternative 1 – No Action

Under Alternative 1, there would be no disturbance in Hart Prairie. As a result, there would be no change in acreage of subalpine grassland either within the SUP area or on the San Francisco Peaks. Past effects to subalpine grasslands in Hart Prairie are discussed in the Cumulative Effects analysis.

Alternative 2 – The Proposed Action

This alternative would result in 2.7 acres of permanent loss, and 18.2 acres of temporary disturbance to subalpine grassland in the SUP. Permanent impacts would be associated with lift realignment/construction, construction of the snowplay area, and construction of facilities associated with snowplay at the upper end of Hart Prairie. Temporary disturbance would consist of recontouring the ground surface, primarily to accommodate the snowplay area near the bottom terminal of the Hart Prairie Chairlift. Disturbed areas would subsequently be reseeded. Due to prior activities, this portion of Hart Prairie already includes introduced plant species such as orchard grass, slender wheatgrass, and timothy. Plant species composition in disturbed and reclaimed areas would likely include more plants and/or biomass of introduced plant species found in seed mixes. Effects of this alternative would be the permanent loss of 7.3 percent, and the temporary disturbance of 49.2 percent of the subalpine grassland in the SUP. Most of the grassland which would be affected was previously disturbed by establishment of *Hart Prairie* (trail #3) and *Aspen Meadows* (trail #1) ski trails and chairlifts. This alternative would result in a permanent loss of approximately 0.3 percent, and the disturbance of 1.7 percent of the subalpine grassland on the San Francisco Peaks.

Alternative 3

This alternative would result in 0.1 acre of permanent loss, and about 17.7 acres of temporary disturbance to subalpine grassland in the SUP associated with lift realignment/construction and recontouring at the upper end of Hart Prairie. Temporary disturbance would consist of recontouring the ground surface near the bottom terminal of the Hart Prairie Chairlift. Elimination of the snowplay area parking lot under this alternative would reduce permanent impacts to subalpine grassland by 2.6 acres and temporary impacts by 0.5 acres as compared with the Proposed Action. Similar to the Proposed Action, reseeding of temporary disturbance areas under this alternative would likely change plant species composition to include more plants and/or biomass of introduced plant species found in seed mixes. Effects of this alternative are the permanent loss of 0.3 percent, and the disturbance of 47.8 percent of the subalpine grassland in the SUP. Most of the grassland affected was previously disturbed by establishment of the *Hart Prairie* (trail #3) and *Aspen Meadows* (trail #1) ski trails and chairlifts. This alternative would result a permanent loss of approximately 0.01 percent and the disturbance of 1.7 percent of the subalpine grassland on the San Francisco Peaks.

Indicator:

Disclosure of Effects to Potentially Occurring Threatened, Endangered, and/or Sensitive Plant Species

Alternative 1 – No Action

Under this alternative, there would be no changes in the analysis area. There would be No Affect on the endangered San Francisco Peaks groundsel or its habitat, including designated critical habitat in the upper portion of the SUP. This alternative would not affect the Forest Service Sensitive bearded gentian, Rusby's milkvetch, or crenulate moonwort. Past impacts to threatened, endangered and sensitive species are further discussed in the Cumulative Effects analysis.

Alternative 2 – The Proposed Action

This alternative would result in disturbance within mapped critical habitat for the threatened San Francisco Peaks groundsel, but would not affect actual habitat or plants Extending, smoothing, and recontouring of existing runs would result in a total of 2.44 acres of disturbance within "mapped critical habitat." However, field review indicates that the proposed disturbance areas lack the necessary affinities to be actual potential habitat. All of this disturbance would take place within spruce-fir forest below timberline. The proposal would therefore not affect individual plants or habitat for the San Francisco Peaks groundsel. There would be about 0.5 acres of disturbance on the talus slope immediately above the Agassiz Chairlift top terminal; this is within the Alpine tundra zone, but no plants have been found in this area and it is outside designated critical habitat. No known plant populations would be impacted by the proposed activities.

Establishing a hiking trail in this area would not increase the number of visitors using the Scenic Sky Ride in the summer months, but it would increase pedestrian activity on the lower slopes of Agassiz Peak. Continued access restrictions, enforcement, monitoring, and construction of interpretive signs along the trail would minimize the potential for impacts to Alpine Tundra and the San Francisco Peaks groundsel.

The Proposed Action may impact individuals of the bearded gentian, but it is not likely to result in a trend toward federal listing or loss of viability. Recontouring and rock/stump removal on *Lower Bowl* (trail #29) and *Sundance* (trail #30) would impact six individuals of the bearded gentian. Relatively few populations of this plant are known. Surveys recently completed by CNF found a total of 57 plants in 18 populations, mostly on the steep southern slopes of Agassiz, Fremont, and Doyle peaks, and in Abineau Canyon.[347] Based on these numbers, about 10 percent of the known population occurs within the SUP, although it is likely that not all plants in either the SUP or the surrounding areas have been found. The CNF may allow the collection of some of these plants for genetic research. Impacts to the overall population would be mitigated by the collection of those plants that would be impacted under this alternative.

The Proposed Action may impact individuals of the Rusby's milkvetch, but it is not likely to result in a trend toward federal listing or loss of viability. Construction activities associated with installation of the reclaimed water pipeline along Snowbowl Road would impact up to 120 plants. Most of the plants located during the survey occur in the drainage area adjacent to the road and would likely be impacted by trench excavation and backfilling operations. Some plants growing further up the hill or cut slope would likely be avoided. The Proposed Action would not affect the population viability of Rusby's milkvetch. This plant occurs in a number of other locations around the Peaks and appears to prefer open and disturbed habitats. This plant is expected to reestablish itself in the project area from the seed bank and/or from recolonization of nearby, unaffected plants.

This alternative would have no impact on the crenulate moonwort or its habitat.

Alternative 3

This alternative would result in disturbance within mapped critical habitat for the threatened San Francisco Peaks groundsel, but would not affect actual habitat or plants. The effects of this alternative would be the same as those described under the Proposed Action.

This alternative may impact individuals of the bearded gentian, but it is not likely to result in a trend toward federal listing or loss of viability. The effects of this alternative would be the same as those described under the Proposed Action.

No reclaimed water pipeline would be constructed along Snowbowl Road under this alternative; therefore, this alternative would have no impact on the Rusby's milkvetch. This alternative would have no impact on the crenulate moonwort or its habitat.

[347] CNF Zone Botanist personal communication., 2003

Vegetation Composition

Issue:

The Proposed Action has potential to change vegetation composition within the SUP area due to the application of machine-produced snow.

Indicator:

Potential Changes to Plant Species Composition Due to the Application of Machine-Produced Snow

Several other indicators were identified pertaining to vegetation issues. Due to their specific relevance to water quality and quantity affects, it was determined that these indicators were most appropriately discussed within the Water Resources section of this chapter.

Alternative 1 – No Action

Under this alternative, there would be no changes in the analysis area and no snowmaking. Vegetation communities in the analysis area would receive only natural precipitation.

Alternative 2 – The Proposed Action

Application of machine-produced snow would result in an overall increase in moisture and nutrients available to plants and may change plant species composition on ski trails within the SUP. Under Alternative 2, machine-produced snow would be applied over 205.2 acres of existing and new ski trails. Application would occur on an annual basis between November and the end of February, extending into March under favorable conditions. Annual total volume of machine-produced snow would average 364 AF per year and would supplement an average annual precipitation volume of about 3,000 AF per year. Nitrogen concentration (as nitrate [$NO3^-$]) in reclaimed water proposed for snowmaking is estimated at 6 mg/L or 428µmol/L. Nitrogen deposition rate with snowmaking would be about 53.5 lbs/acre/yr on average within the Snowbowl Sub-watershed (Table 3J-4). Snowmaking on the 205.2 acres of ski trails in the SUP is estimated to add 31.1 lbs/acre/yr of nitrogen over historic natural deposition.[348]

Table 3J-4
Volume of Snow-making and Nitrogen Deposition Rate within the Snowbowl Sub-watershed in Dry, Average, and Wet Years

Condition	Snowmaking Volume	Background N Depositional Rate	N Deposition Rate with Snowmaking
Dry Year	486 acre-feet/year	9.23 lbs/acre/yr	50.76 lbs/acre/yr
Average Year	364 acre-feet/year	22.41 lbs/acre/yr	53.51 lbs/acre/yr
Wet Year	243 acre-feet/year	34.18 lbs/acre/yr	54.97 lbs/acre/yr

Additional water and nitrogen from snowmaking would increase plant growth and may change plant species composition on existing and newly developed ski trails. Several studies have looked specifically at the effects of nitrogen loading on soils and plant

[348] Schwartzman and Springer, 2002

communities as a result of applying reclaimed water or nitrogen fertilizers. These studies are summarized in Table 3J-5. They have generally documented initial nitrogen retention in the soil due to increased assimilation by plants and microorganisms, followed by rapid leaching of nitrates to the groundwater as an assimilation threshold is reached.[349]

Effects of supplemental nitrogen on plant communities on ski trails would be dependent on local conditions, nitrogen concentrations in the reclaimed water, and deposition rates. The rate of nitrogen saturation of the soil would be dependent on a number of factors, including soil physical and chemical characteristics, existing soil nutrient content, plant species diversity and density, and climate. Net nitrogen deposition as a result of snowmaking in the SUP would be from about two-fold to over 60-fold lower than that in the studies cited. Therefore, nitrogen saturation would likely occur over a longer time period. As soils in the SUP reach the assimilation threshold, there may be a shift in dominance of plant species or a change in plant species composition on the cleared ski trails. The availability of additional moisture and nitrogen would likely increase the net primary productivity and dominance of early successional or weedy plant species. This may reduce overall plant species diversity in some portions of the SUP. The combined effects of construction activities and additional moisture and nutrients have potential to increase the local abundance of noxious weeds in the SUP.

Potential changes in plant species composition or dominance would be limited in part by the characteristics of the affected plant communities. Historically, the majority of existing ski trails have been seeded with commercial seed mix species, which have become well established. Most of the seed mix species are early seral (successional) annual and perennial plants that exhibit rapid growth under favorable nutrient and moisture conditions. Increased moisture and nitrogen from snowmaking would therefore be expected to increase the biomass or cover of the existing plant community on the ski trails. These conditions may differentially enhance the growth of forbs over that of the perennial cool-season grasses.[350] Since very little vegetative cover on reclaimed ski trails consist of native perennial, mid- to late seral plant species, no substantial change in native plant species diversity would occur in most of the area affected by snowmaking. Reduction of native plant species diversity may occur in areas where native perennial, mid- to late seral species are still important, such as *Hart Prairie* (trail #3) and some of the less disturbed ski trails, such as *Casino* (trail #23). The spatial extent of these potential effects would be dependent on hydrologic characteristics.

[349] Jordan et al., 1997 and McNulty et al., 1996 and Dise and Wright, 1995 and Aber et al., 1998 and Currie et al., 1996 and Rueth et al., 2003

[350] Reed, 1977 and Kirchner, 1977

Table 3J-5
Summary of Studies on the Effects of Nitrogen Addition on Plant Communities

Study/location	Plant community	Application (kg/ha/yr) (lbs/acre/yr)	Application type	Duration (yr)	Results
Sopper (1971) Pennsylvania	Mixed oak stand Red pine plantation Old field	393 2,122	Municipal wastewater	6	No effect on red pine. Increased diameter growth of mixed hardwood species. Height increase in white spruce saplings in old field. Increase in height, density, and dry matter production of herbaceous groundcover.
Chadwick et al. (1974) England	Lowland heath	613 3,310	Polluted river water	2	Increased dry matter production of herbaceous groundcover. No change in plant species composition.
Reed (1977) Michigan	Old field	450 2,430	Dry fertilizer	1	Increased dry matter production of herbaceous groundcover. Reduction in plant species richness. Shift in dominance to C3 dicots.
Kirchner (1977) Colorado	Short-grass prairie	150 810	Dry fertilizer and water	3	Increased dry matter production of C4 plants. Reduction of plant species diversity through shift in dominance to earlier seral species. Increase in arthropod diversity and biomass.
Hunt and Shure (1980) South Carolina	Pine forest	nm (5.3cm/wk applied)	Industrial wastewater	4	Increased dry matter production of herbaceous groundcover. Reduction of plant species diversity through shift in dominance to earlier seral C3 species. Increase in arthropod diversity and biomass.
McNulty et al. (1996) Vermont	Spruce-fir forest	15.7 – 31.4 84.7 – 169.5	Dry fertilizer	7	Initial increase in basal diameter growth of red spruce and birch, subsequent increased mortality of red spruce. Predicted shift in dominance from evergreen to deciduous species.
Jordan et al. (1997) Massachusetts	Pine forest Oak forest Old field	370 – 480 1,998 – 2,592	Municipal wastewater	2	Increase in dry matter production in pine forest, but no change detected in oak forest. Reduction in shrub biomass and shift in dominance to early seral forbs (weedy species) in old fields.
Magill et al (1996) Maine	Mixed deciduous forest	18 – 61 97 - 329	Dry fertilizer	4	Increase in mean wood production. Increased tree mortality at low and high N application rates, resulting in decline in cumulative biomass over the study period.

Local patterns of run-off and infiltration influence the spatial extent over which changes in plant species composition would occur. Snowpack moisture not lost to sublimation predominantly infiltrates the permeable soils in the SUP to reach shallow perched aquifers. Little surface runoff occurs in the SUP or areas downstream of the SUP. The effects of added moisture and nitrogen on plant communities in the SUP would therefore be localized. It is noted that, in one study, weedy plant species persisted after nine years of irrigation with reclaimed water, but did not spread beyond the treated area.[351] The extent to which added moisture and nutrients influence plant species composition in the SUP would be largely restricted to the cleared ski trails, with limited impacts to the adjacent spruce-fir forest. It was noted a decline in mature spruce and fir trees and increased mortality of seedlings after seven years of nitrogen fertilization at rates between 84.7 – 169.5 lbs/acre/year (15.7 and 31.4 kg/ha/year).[352] This rate is two to three times greater than would occur under this alternative. Nevertheless, some mortality of spruce and fir trees may occur along the edges of the cleared ski runs. Because most of the snowpack would infiltrate in-place, trees in the interior of spruce-fir stands would not be affected.

Alternative 3

This alternative would not include snowmaking. Therefore the effects would be the same as those described in Alternative 1.

CUMULATIVE EFFECTS

Scope of Analysis

Temporal Bounds

The temporal bounds of the cumulative effects analysis for vegetation extend from the initial development of Snowbowl as a winter recreational area into the foreseeable future during which recreation-related activities may affect vegetation.

Spatial Bounds

The physical extent of this cumulative effects analysis comprises mainly the Snowbowl SUP area, the proposed reclaimed water pipeline alignment between the City of Flagstaff and the SUP, and adjacent public lands to the extent they would be potentially affected. These adjacent lands include a portion of the Kachina Peaks Wilderness, areas adjacent to the reclaimed water pipeline alignment, and areas downslope of the SUP area (primarily Hart Prairie). Other projects in the Peaks area that affect vegetation are also included in the cumulative effects analysis.

Past, Present, and Reasonably Foreseeable Future Actions

1. Development and Maintenance of the SUP as a Recreational Area
2. Spruce Bark Beetle Control within the SUP
3. Kachina Peaks Wilderness Area Designation
4. Bebbs Willow Restoration Project

[351] Jordan et al., 1997

[352] McNulty et al., 1996

5. Fort Valley Restoration Project
6. Transwestern Lateral Pipeline Project
7. Peaks Segment of the Arizona Trail
8. Private Land Development
9. Miscellaneous/ongoing Recreational Uses
10. Power Line Maintenance
11. Various Aspen Regeneration and Exclosure Fences
12. Inner Basin Waterline Pipeline Maintenance
13. Snowbowl Road Paving

Appendix C includes the full list of past, present and reasonably foreseeable future actions analyzed in this document, as well as background information on each of them.

Alternative 1 – No Action

Plant Communities

Cumulative effects of the No Action alternative on plant communities are primarily related to past development of the SUP area as a winter recreational area; past, present and future maintenance activities within the SUP to support recreational uses; and natural events and measures implemented to control a spruce bark beetle outbreak. Effects of these activities on plant communities are limited to the SUP area. Other projects in the Peaks area also contribute to cumulative effects on plant communities.

Both management activities and natural events have influenced plant communities in the analysis area. Since inception of the ski area, approximately 160 acres of natural vegetation within the SUP have been modified for recreational use. Of this total, approximately 139 acres have been modified for the establishment and maintenance of dedicated ski trails as well as for support facilities and associated infrastructure. Most the clearing has affected spruce-fir forest, but approximately 17 acres of subalpine grassland was disturbed for the establishment and maintenance of the *Hart Prairie* (trail #3) and *Aspen Meadows* (trail #1) ski trails and chairlifts. In order to rapidly stabilize disturbed soils, reclamation of ski runs has used commercial seed mixes dominated by non-native species (refer to Table 3J-6). As a result, species composition on revegetated ski trails is predominantly non-native. Native species from adjacent or nearby undisturbed areas have not substantially recolonized the ski trails. Conversely, non-native species have not substantially spread to adjacent or nearby undisturbed areas.[353]

Periodic maintenance activities within the SUP area include the removal of obstructions and the repair of erosion control features on ski trails and the removal of hazard trees. These activities have had little effect on overall plant community structure or composition.

Measures to control the spruce bark beetle represent a cumulative effect on plant communities in the SUP area. Spruce bark beetles have affected stands of spruce-fir and mixed conifer in the SUP. A cyclonic wind event in the fall of 1999 resulted in a blow down of approximately 25 acres of spruce-fir along the upper portion of the Agassiz

[353] SWCA ,1996a and Van Ommeren, 2001

Chairlift. This triggered a localized outbreak of the spruce bark beetle which has infected an estimated 1,000 trees. The CNF has implemented a treatment program which involves

Table 3J-6
Plant Species Included In Seed-Mixes for Ski Trail Reclamation

Common Name	Scientific Name	Status
Slender wheatgrass	Agropyron trachycaulum	Exotic
Mountain brome	Bromus marginatus	Native
Timothy	Phleum pratense	Exotic
Sheep fescue	Festuca ovina	Native
Creeping red fescue	F. rubra	Native
Canada bluegrass	Poa compressa	Exotic
Orchard grass	Dactylis glomerata	Exotic
Small burnet	Sanguisorba minor	Exotic
Hairy vetch	Vicia villosa	Exotic
Birdsfoot trefoil	Lotus corniculatus	Exotic
Clover	Trifolium hybridum	Exotic
Wooly pod vetch	Vicia dasycarpa	Exotic

felling infected trees and the subsequent peeling of the bark to expose and kill beetle larvae. The CNF is also applying an anti-aggregation pheromone to control the spread of bark beetles to adjacent stands of trees. About 150 trees were treated in 2002 and an additional 800 were identified for future treatment. At this time, the spruce bark beetle outbreak is confined to a relatively small area and has not spread to other stands of trees within the SUP area or the adjacent Kachina Peaks Wilderness Area. Western balsam bark beetle has infected some corkbark fir near Agassiz Lodge, but no treatment has been implemented to date.

Other actions or projects have affected, or have the potential to affect plant communities in the analysis area. Designation of the Kachina Peaks Wilderness Area in 1984 has resulted in the protection of 18,705 acres of high elevation montane conifer forest and grasslands on the Peaks. Construction of the Transwestern Lateral Pipeline in 1992 resulted in the removal of approximately four acres of predominantly ponderosa pine forest on the south slopes of the Peaks. The ongoing Bebbs Willow Restoration Project includes prescribed burning and thinning of 600 acres of ponderosa pine forest to aid the restoration of a montane riparian plant community. The Fort Valley Restoration Project is thinning approximately 9,100 acres of ponderosa pine forest on the lower south and west slopes of the Peaks. Various fenced plots, totaling about 400 acres, have been established to promote the regeneration of aspen on the Peaks. Development of private lands in Lower Hart Prairie is affecting primarily plains and montane grassland. Maintenance along the power line from Snowbowl Road results in the occasional removal of hazard trees and other vegetation along roughly three acres of right-of-way. Miscellaneous recreational uses on the Peaks contribute primarily temporary impacts on plant communities.

Threatened, Endangered, and Sensitive Species

Recreational use on the Humphreys Trail in the Kachina Peaks Wilderness Area has resulted in some impacts to the sensitive alpine tundra in the past. However; improved trail markings have minimized those impacts. Recreational activity related to the Scenic Sky Ride within the SUP area has been restricted and monitored to prevent access to Alpine tundra areas. Under the No Action alternative, closures and trail restrictions would continue to protect this species and also habitat for the sensitive bearded gentian. Past and future avalanche control activities do not result in cumulative effects on plant species. The primary focus of avalanche control is to cause smaller, more frequent and less damaging slides. These tend to run on snow layers higher in the snowpack. In contrast, naturally-occurring avalanches tend to run on the ground surface and therefore have the potential to disturb soil substrates and plants directly.

Several projects in the Peaks area have the potential to affect the Forest Service sensitive Rusby's milkvetch. The proposed repair of the City of Flagstaff's Inner Basin Waterline across Schultz Pass may impact up to 200 plants near the Weatherford Trail. The proposed Peaks Segment of the Arizona Trail will impact habitat for Rusby's milkvetch. The ultimate trail alignment will be adjusted to avoid directly impacting individual plants. The Fort Valley Ecosystem Restoration Project would impact some Rusby's milkvetch. All of these projects will result in temporary ground disturbance. Since Rusby's milkvetch is often found along disturbed trails and roadways, the cumulative effects of these projects and the continuation of current management practices under the No Action Alternative will be unlikely to affect the population viability of this species or result in a trend toward federal listing.

Noxious Weeds

Under the No Action alternative, past development, maintenance, and recreational activities have likely increased the local abundance of noxious weeds within the SUP area. Noxious weeds are spread through the use of mechanized equipment and vehicles for clearing, grading, erosion control, and hazard removal on the ski trails, maintenance of existing roadways in the SUP area, and maintenance of the power line from Snowbowl Road to the SUP area. Miscellaneous recreational activities such as weddings, reunions, recreation events, hiking, and bicycling also have the potential to contribute to the introduction or spread noxious weeds. Since the spread of noxious plant species is dependent on disturbance, these activities have not affected undisturbed adjacent areas within the SUP area or in the Kachina Peaks Wilderness Area. Other past, present, and future projects in the Peaks area contribute disturbance of 10,100 acres of Forest land (including Bebbs Willow Restoration Project, Fort Valley Restoration Project, and Aspen Regeneration Projects), 26 miles of pipeline right-of-way (Transwestern Lateral Pipeline, and Inner Basin Water Pipeline), 12 miles of roadway (Snowbowl Road paving), five miles of power line right-of-way (power line maintenance and Snowbowl Road to SUP), 31 miles of trail (Peaks segment of the Arizona Trail), Forest lands affected by other recreational uses, and an unknown number of acres of private land (private land development and , Lower Hart Prairie). The effects of these projects on the actual or potential establishment and spread of noxious weeds vary. The paving of the Snowbowl Road resulted in the establishment and spread of noxious weeds due to the use of imported fill. Initial development of the ski area occurred prior to active management and monitoring of noxious weeds by the CNF. Development of private lands is not subject to Forest Service directives regarding noxious weeds and therefore has a greater potential effect. Recent, ongoing, and future projects on Forest lands are subject to mitigation measures for the control of noxious weeds and therefore contribute substantially less to their potential establishment and proliferation.

Alternative 2 – The Proposed Action

Plant Communities

Cumulative effects of the Proposed Action on plant communities are expected to be the same as those described under Alternative 1, with the following exceptions.

The cumulative effect of past ski area development and proposed additional development under the Proposed Action would be the removal, disturbance, or modification of approximately 305.6 acres of montane conifer forest and grassland within the SUP area. This consists of roughly 160 acres affected as a result of past ski area development and proposed improvements that would remove an additional 76.3 acres of spruce-fir forest, remove 2.7 acres and temporarily disturb 18.2 acres of subalpine grassland, and thin 48.4 acres of spruce-fir forest within the SUP area. Approximately 150 trees have already been removed from the SUP area for the control of spruce bark beetles. The total area within the SUP area subject to maintenance activities (such as erosion control and hazard tree removal) would increase from 138.6 acres (i.e., existing dedicated ski trails) to 233.1 acres to encompass new ski trails and other recreational use areas. The increased area subject to maintenance activities would consist of approximately 76.3 acres of spruce-fir forest and 18.2 acres of subalpine grassland. Under this alternative, the total area subject to reclamation with (and establishment of) predominantly non-native grasses and forbs would increase from 138.6 acres (existing ski trails) to 233.1 (new ski trails and recreational use areas).

Threatened, Endangered, and Sensitive Species

Cumulative effects of the Proposed Action on threatened, endangered, and sensitive species are expected to be the same as those described under Alternative 1, with the following exceptions.

The Proposed Action would result in the removal of approximately six bearded gentian plants from the SUP. The remainder of the known population of this sensitive plant species occurs within the Kachina Peaks Wilderness Area and is protected by trail closures, access restrictions, and monitoring. The Proposed Action would impact up to 120 Rusby's milkvetch along Snowbowl Road. Other individuals of this plant species were likely impacted during the paving of the Snowbowl Road and individuals and/or habitat will be impacted by the proposed repair of the Inner Basin Waterline across Schultz Pass, construction of the Arizona Trail, and implementation of Fort Valley Ecosystem Restoration Project. All of these projects, including the Proposed Action, would result in temporary ground disturbance and are unlikely to affect the population viability of this species or result in a trend toward federal listing.

Noxious Weeds

Cumulative effects of the Proposed Action with regard to noxious weeds are anticipated to be the same as those described under Alternative 1, with the following exceptions.

This alternative would increase the area actively managed for recreation within the SUP area from 160 acres to 305.6 acres and would increase the total area of disturbance in which noxious weeds could become established or proliferate. Construction of the reclaimed water pipeline would result in temporary disturbance along 14 miles between the City of Flagstaff and the SUP.

Alternative 3

Plant Communities

Cumulative effects of the Proposed Action on plant communities are anticipated to be the same as those described under Alternative 1, with the following exceptions.

The cumulative effect of past ski area development and proposed additional development under this alternative would be the removal, disturbance, or modification of 274.9 acres of montane conifer forest and grassland within the SUP area. This consists of 160 acres affected as a result of past ski area development and proposed improvements that would remove an additional 66.4 acres of spruce-fir forest, remove 0.1 acre of subalpine grassland, and thin 48.4 acres of spruce-fir forest within the SUP area. The total area within the SUP area subject to maintenance activities (such as erosion control and hazard tree removal) would increase from 138.6 acres (i.e., existing dedicated ski trails) to 205 acres to encompass new ski trails and other recreational use areas. The increased area subject to maintenance activities consist of 66.4 acres of spruce-fir forest. Under Alternative 3, the total area subject to reclamation with (and establishment of) predominantly non-native grasses and forbs would increase from 138.6 acres (existing ski trails) to 205 (new ski trails and recreational use areas).

Threatened, Endangered and Sensitive Species

Cumulative effects of this alternative are the same as those described under alternatives 1 and 2, except that this alternative would not contribute to cumulative effects to the Forest Service sensitive Rusby's milkvetch.

Noxious Weeds

This alternative would increase the area actively managed for recreation within the SUP area from 160 acres to 274.9 acres and would increase the total area of disturbance in which noxious weeds could become established or proliferate. No reclaimed water pipeline would be constructed between the SUP area and the City of Flagstaff. Otherwise, cumulative effects are the same as those described under Alternative 1.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

No irreversible or irretrievable effects or commitment of vegetation resources would occur as a result of implementation of the Proposed Action or Alternative 3. Proposed changes in the analysis area do not preclude potential future restoration activities.

3K. WILDLIFE

SCOPE OF THE ANALYSIS

The analysis area for threatened, endangered, and sensitive wildlife; migratory birds; and game and non-game wildlife includes the Snowbowl SUP, Snowbowl Road, the proposed reclaimed water pipeline alignment between the City of Flagstaff and the SUP, and adjacent areas. Because the Snowbowl SUP is managed as a recreation site, analysis of impacts to management indicator species is limited to areas adjacent to the SUP (Kachina Peaks Wilderness area) and to areas along and adjacent to the Snowbowl Road and reclaimed water pipeline alignment.

EXISTING CONDITIONS

THREATENED, ENDANGERED, AND SENSITIVE SPECIES

The threatened, endangered, and sensitive Species (TES) list for the Mormon Lake and Peaks Ranger District was reviewed and a TES list for this project was created in July 2002. One federally-listed threatened wildlife species occurs regularly within general the analysis area: Mexican spotted owl (Strix occidentalis lucida). The threatened bald eagle (Haliaeetus leucocephalus) may occur in the analysis area in winter. The endangered black-footed ferret (Mustela nigripes) is not known or expected to occur in the analysis area. Critical habitat for the Mexican spotted owl on NFS lands was proposed for listing November 18, 2003. There is no designated or proposed critical habitat for any other listed or proposed wildlife species. The analysis area includes habitat for two Forest Service sensitive species: Navajo Mountain Mexican vole (Microtus mexicanus navaho) and northern goshawk (Accipiter gentilis). There is no habitat in the analysis area for the Region 3 Forest Service sensitive peregrine falcon (Falco peregrinus anatum). Sensitive species that have been eliminated from further analysis due to lack of habitat are listed in Table 3K-1.

A Biological Assessment/Biological Evaluation (BA/BE) was prepared for this project and will be submitted to the U.S. Fish and Wildlife Service (USFWS) for concurrence with the determination of effects to T and E species. The Forest Service will also review and approve the BE according to its determinations for sensitive species.

Table 3K-1
Forest Service Sensitive Wildlife Species Eliminated from Further Analysis

Common Name	Scientific Name
Wupatki Arizona Pocket Mouse	Perognathus amplus cineris
Narrow-headed Garter Snake	Thamnophis rufipunctatus
Northern Leopard Frog	Rana pipiens
Arynxa Giant Skipper	Agathymus aryxna
Freeman’s Agave Borer	Agathymus baeuri freemani
Early Elfin	Incisalia fotis
Spotted Skipperling	Piruna polingii
Mountain Silverspot Butterfly	Speyeria nokomis nicrotis
Blue-black Silverspot Butterfly	Speyaria nokomis nokomis

Mexican Spotted Owl (*Strix occidentalis lucida*) - Threatened

The Mexican spotted owl was listed as a threatened species in 1993. On the CNF, this species occupies mixed conifer and ponderosa pine-gambel oak vegetation types, usually characterized by high canopy closure, high stem density, multi-layered canopies within the stand, numerous snags, and down woody material. The CNF lies within the Upper Gila Mountain Recovery Unit.

Primary threats to Mexican spotted owls within the Upper Gila Mountain Recovery Unit include timber harvest and catastrophic wildfire, fuelwood cutting, and grazing.[354] Effects of recreation on Mexican spotted owls and habitat are described in the Recovery Plan and relate to recreation indirect habitat disturbance from recreation, as well as the presence and intensity of allowable recreation activities and spatial and temporal restrictions for the owl.[355]

The majority of the SUP supports spruce-fir forest and is therefore not suitable nesting habitat for Mexican spotted owls. A limited area in the southwest corner of the SUP is mapped as mixed conifer forest, which is classified as Restricted Area in the Recovery Plan. The northwest corner of the SUP (i.e., the upper extent of Hart Prairie) supports subalpine grassland. No Mexican spotted owls (MSO) have been detected within the SUP during consecutive surveys conducted since 1990.

Two MSO Protected Activity Centers (PACs) have been established adjacent to and along the Snowbowl Road, south of the SUP. The Snowbowl PAC is located approximately one to two miles from the SUP. The extreme southwest corner of the SUP is approximately 5,000 feet, or about one mile, in linear distance from the northern-most boundary of this PAC. An approximately 1.5-mile segment of Snowbowl Road is located within the boundaries of this PAC. This PAC has supported owls since 1985 and was occupied in 2003. Since 1992, four known nest sites have been identified within this PAC, ranging in linear distance from about 150 feet to 1,500 feet from Snowbowl Road and 5,000 to 7,500 feet from the southern SUP boundary. Owls using this PAC generally fledge young by the end of June or early July. Fledglings remain near the adults through summer and early fall. The adults are thought to remain in the general area throughout the year.[356]

The Veit Spring PAC extends from the southwest corner of the SUP approximately one to 1.5 miles to the south. Approximately five acres of this PAC overlaps the SUP, in the extreme southwest corner. A section of Snowbowl Road approximately 300-feet in length is within the extreme southwestern PAC boundary; generally this PAC is located 500 to 1,000 feet east of the roadway. The Veit Spring PAC was established in 1997 based on detection of a single roosting male in 1996. This is believed to have been a subadult dispersing from a nearby PAC. No MSOs have been detected since that time, and this PAC is believed to have been unoccupied for the last seven years.[357]

[354] USDI, 1995
[355] Id.
[356] Wildlife Biologist, pers. comm. 2003
[357] Arizona Biological Surveys, 2003

Bald Eagle (*Haliaeetus leucocephalus*) - Threatened

Bald eagles are primarily winter visitors to the CNF, occupying all habitat types and elevations. Wintering eagles arrive in the fall, usually late October or early November, and leave in early to mid-April. They feed on fish, waterfowl, terrestrial vertebrates, and carrion. Eagles are often seen perched in trees or snags near water or next to roadways where they feed on road-killed animals. At night, small groups (usually two to 12) or individual eagles roost in clumps of large trees in protected locations such as drainages and hillsides. Eagles usually roost adjacent to or very near food sources.

There are no known nesting areas in the project vicinity. The nearest documented breeding areas are along the upper Verde River, about 35 miles southwest of Flagstaff. Wintering bald eagles may occur occasionally in or near the project area. Perched eagles are sometimes observed in the Flagstaff vicinity, including Fort Valley. Most eagles are seen in ponderosa pine forest, but they are occasionally reported from mixed conifer and spruce-fir forest. The SUP supports mixed conifer and spruce-fir forest and is expected to be rarely visited by eagles in winter. There are two known roost sites in the general project vicinity. A summer roost occurs near Dry Lake, approximately three miles south of the proposed reclaimed water pipeline. A winter roost is located eight miles east of the project area. Bald eagles have been observed perching in snags and dead-topped trees at the fringes of the Fort Valley meadow, including the lower portion of the Snowbowl Road, and near Baderville, Rodgers Lake, Interstates 40 and 17, and Bellemont. There are no significant water bodies in the project vicinity, although eagles may feed on mammalian prey in these areas.

Black-footed Ferret (*Mustela nigripes*) - Endangered

Black-footed ferrets occurred historically in northern Arizona, where their range apparently overlapped that of their primary prey, the Gunnison's prairie dog (*Cynomys gunnisoni*). Wild populations of this species are believed to have been extirpated from the state early in the twentieth century as a result of prairie dog control programs.[358] The only records for the region are one from 1917 at Bacas Ranch, 16 miles northeast of Springerville, Arizona and another record seven miles northeast of Williams in 1929.[359] A report[360] also documented an occurrence from Government Prairie near Parks and another from 12 miles west of Winona.

There are no records of black-footed ferrets in the analysis area. There is one known Gunnison's prairie dog town within the SUP area. This town is currently active and was estimated to cover about 50 acres in 2002.[361] This is one of six towns that make up a complex. This town was surveyed in 1993 and 1994, but no black-footed ferrets were found. Other prairie dog towns occur in the Flagstaff vicinity.

Prairie dog populations are cyclic and can go from huge numbers to almost no animals within a short time due to disease, weather patterns, predation, and other factors. Population numbers fluctuate yearly, with high numbers in some years and undetectable

[358] AGFD, 1996 and Hoffmeister, 1986
[359] Hoffmeister, 1986
[360] Cockrum, 1960
[361] Northland Research, 2003

numbers present in other years. Bubonic plague has been a significant factor in prairie dog colonies in the Flagstaff area in recent years and many recently active colonies have been severely impacted. Other impacts to prairie dogs include predation by coyotes, raptors, and bobcats and legal shooting.

Navajo Mountain Mexican Vole (*Microtus mexicanus navaho*) - Sensitive

Navajo Mountain Mexican voles are found in dry grassy areas in or adjacent to pinyon-juniper woodlands; sagebrush shrublands; and ponderosa pine, mixed conifer forest, and spruce-fir forest in northern Arizona.[362] Navajo Mountain Mexican vole distribution is only known from Navajo Mountain (on the Arizona-Utah border), the south rim of the Grand Canyon, and the Flagstaff and Williams areas.[363] Locations have been reported from 3,800 to 9,700 feet elevation with a number of locations around the San Francisco Peaks. On the San Francisco Peaks, this vole has been found in open grassy areas amid limber pine, spruce, fir, and aspen. They are generally active mid-day and in early evening, but may also be active at night or in winter, depending on temperature.[364] Moisture conditions and the amount of cover are thought to influence the local distribution of voles in the genus Microtus.[365]

Several surveys have been conducted within the Snowbowl SUP. Although no individual Navajo Mountain Mexican voles have been see, numerous signs of their existence were observed. Runways have been found on *Lower Bowl* (trail #29), *Sundance* (trail #30), *White Lightning* (trail #28), *Upper Ridge* (trail #26), *Lower Ridge*(trail #21), *Upper Casino* (trail #23) and in the tree islands between the Hart Prairie Lodge parking lots.

The main threat to the Navajo Mountain Mexican vole is reduced ground cover resulting from increased tree density, grazing or periodic droughts. Recreation use has the potential to reduce habitat for this species.

Northern Goshawk (*Accipiter gentilis*) - Sensitive

Northern goshawks nest in coniferous forest in the mountains and on the high plateaus, including the Kaibab Plateau, the San Francisco Peaks, Flagstaff area, Mogollon Rim, the White Mountains of eastern Arizona, and the high mountain ranges of southeastern Arizona.[366] The northern goshawk is a forest habitat generalist that uses a wide variety of forest stages in ponderosa pine and mixed conifer habitat. It prefers stands of intermediate canopy cover for nesting and more open areas for foraging. All ponderosa pine and mixed conifer above the rim is considered northern goshawk habitat, including associated pine or mixed conifer stringers that may extend below the rim.

Northern goshawk foraging occurs predominantly in ponderosa pine vegetation. Although juniper or pinyon-juniper habitat types are not heavily used by northern goshawks, some foraging may occur there, especially in transition areas between

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[362] Arizona Game and Fish Department, 1996 and Hoffmeister, 1986

[363] Hoffmeister 1986, District records

[364] Hoffmeister, 1986; Northland Research, 2003

[365] Kime et al., 1994

[366] Arizona Game and Fish Department, 1996; Snyder and Snyder, 1998

ponderosa pine and pinyon-juniper habitats. The northern goshawk preys on large to medium sized birds and mammals.

Nest stands are typically in later successional stages, especially old-growth trees. Nest building begins in March and young are typically fledged by the early part of June.[367] Post-fledgling family areas (PFAs) have patches of dense trees, developed herbaceous or shrubby understories, snags, downed logs, and small openings, which provide cover and prey. Fledglings develop their hunting skills here. Foraging areas are a mosaic of various successional stages and cover types.

There are two PFAs within the analysis area, both of which are located along the Snowbowl Road and the reclaimed water pipeline alignment. The Veit Spring PFA largely overlaps the Snowbowl Mexican spotted owl PAC. There are no recent surveys or monitoring data for this PFA, but it is presumed occupied. The Mars Hill PFA is located north and west of Lowell Observatory, with portions on CNF land, private land, and Arizona State Trust Lands. Only observatory lands within the Mars Hill PFA have been surveyed. The only known nest is located within 0.2 miles of the reclaimed water pipeline alignment.

Threats to northern goshawks are generally related to timber management. However, fire suppression, catastrophic fire, livestock grazing, drought, and toxic chemicals may also be involved. Declines may be related to decreases in prey populations associated with changes in structure and composition of forests.

American Peregrine Falcon (*Falco peregrinus anatum*) - Sensitive

The peregrine falcon was removed from the Federal List of Endangered and Threatened Wildlife in August 1999, and it is now a Region 3 Forest Service sensitive species.[368] The essential habitat for the peregrine falcon includes rock cliffs for nesting and a large foraging area. Suitable nesting sites occur on rock cliffs with a mean height of 200 to 300 feet. The subspecies anatum breeds on isolated cliffs and is a permanent resident on the CNF. Peregrines prey mainly on birds found in wetlands, riparian areas, meadows within a 10 to 20 mile radius from the nest site. The peregrine breeding season is from March 1 to August 31.

The project area includes vegetation communities ranging from ponderosa pine forest at lower elevations to mixed conifer forest, spruce-fir forest, subalpine grassland, and alpine tundra at higher elevations on the Peaks. The analysis area lacks steep cliff sites potentially suitable for nesting by this species. Peregrine falcons are not known to nest in the project area or its immediate vicinity. The nearest known active eyrie is located over five miles away from the SUP, Snowbowl Road, and any portion of the reclaimed water pipeline alignment.

The main threat to the peregrine falcon is the continued contamination of its environment by synthetic organochlorine contaminants (e.g., DDT). These contaminants result in

[367] Snyder and Snyder, 1998

[368] USDI, 1999

eggshell thinning and direct mortality to this species. Other threats include disturbance from rock-climbing near eyries and mortality from encounters with power lines.

MANAGEMENT INDICATOR SPECIES

The 1982 National Forest Management Act Regulations set forth a process for developing, adopting, and revising land and resource management plans for the National Forest System, and identify requirements for integrating fish and wildlife resources in Forest Land Management Plans.[369] Key provisions for fish and wildlife resources require that fish and wildlife habitat be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area, where a viable population is considered to be one that has the estimated numbers and distribution of individuals to ensure its continued existence is well distributed through the planning area.[370] By definition, the planning area is the area covered by a regional guide or forest plan.[371] The Forest Planning Regulations require that certain species, whose population changes are believed to indicate the effects of management activities, be selected and evaluated in forest planning alternatives.[372] Additionally, the Planning Regulations require that the population trends of management indicator species be monitored and relationships to habitat changes determined.[373]

Specific management direction for Management Indicator Species (MIS) is also found in Forest Service Manual (FSM) 2600. Policy and direction that tiers to 36 CFR 219.19 is provided for MIS for application at the Forest Plan and project levels relative to species selection, habitat analysis, monitoring and evaluation, and other habitat and planning evaluation considerations, in FSM 2620. FSM 2630 provides guidance on improving MIS habitat, and conducting habitat examinations, and project level evaluations for MIS within the project area. Management indicator species were identified for each of the management areas described in the Forest Plan.[374] There are no MIS identified for Developed Recreation Areas (i.e., the Arizona Snowbowl SUP). As a result, this analysis incorporates other Management Areas. Table 3K-2 describes the MIS and the vegetation types they are indicators for. Some species have already been discussed in previous sections of this document and will not be discussed further here: northern goshawk and Mexican spotted owl. Table 3K-3 lists other MIS that were considered, but dropped from detailed analysis because habitat does not exist in the analysis area.

Abert Squirrel (*Sciurus aberti*)

The Forest Plan designates the Abert squirrel as an MIS for early seral stage ponderosa pine forests. More recent research indicates that this species best habitat is the intermediate to older aged forest (trees nine to 22 inches DBH, with trees from 18 to 22 inches DBH preferred), where groups of trees have crowns that are interlocking or close. Populations of this species are considered stable in the state, although population trends

[369] CFR 219.1, CFR 219.13, CFR 219.19
[370] CFR 219.19
[371] CFR 219.3
[372] CFR 219.19
[373] Id.
[374] USDA, 1987

on the CNF are unknown. Uneven-aged stand management is thought to benefit the Abert squirrel. Heavy thinning, such as that which occurs at the urban-interface and as part of restoration treatments, reduces habitat quality due to resulting low tree densities and a lack of interlocking tree crowns.[375] Within the analysis area, dense stands of ponderosa pine suitable for Abert squirrels occur along the lower portion of Snowbowl Road and the proposed reclaimed water pipeline alignment.

[375] USDA, 2002

Table 3K-2
Coconino National Forest Management Indicator Species

Management Area (MA)	Species	Habitat
MA 3 (Ponderosa Pine and Mixed Conifer with <40 percent Slopes), MA 4 (Ponderosa Pine and Mixed Conifer with >40 percent Slopes), and MA 6 (Unsuitable Timber Land in Ponderosa Pine)	Abert Squirrel	Early seral ponderosa pine
MA 3 and MA 4	Northern Goshawk	Late seral ponderosa pine
MA 3 and MA 4	Pygmy Nuthatch	Late seral ponderosa pine
MA 3 and MA 4	Turkey	Late seral ponderosa pine
MA 3, MA 4, and MA 6, and MA 7 (Pinyon-juniper Woodland with <40 percent Slopes) and MA 8 (Pinyon-juniper Woodland with >40 percent Slopes)	Elk	Early seral ponderosa pine, mixed conifer, and spruce-fir
MA 3, MA 4, and MA 6	Hairy Woodpecker	Snag component of ponderosa pine, mixed conifer, and spruce-fir
MA 3 and MA 4	Mexican Spotted Owl	Late seral mixed conifer and spruce-fir
MA 3 and MA 4	Red Squirrel	Late seral mixed conifer and spruce-fir
MA 5 (Aspen)	Yellow-bellied (Red-naped) Sapsucker	Late seral and snag component of aspen
MA 5 and MA 6 and MA 7 (Pinyon-juniper Woodland with <40 percent Slopes) and MA 8 (Pinyon-juniper Woodland with >40 percent Slopes)	Mule Deer	Early seral aspen and pinyon-juniper
MA 7 and MA 8	Juniper (Plain) Titmouse	Late seral and snag component of pinyon-juniper
MA 9 (Mountain Grasslands)	Elk, Pronghorn Antelope	Early and late seral grasslands
MA 10 (Grassland and Sparse Pinyon-juniper)	Pronghorn Antelope	Early and late seral grasslands
MA 12 (Riparian and Open Water)	Lincoln’s Sparrow	Late seral, high elevation riparian (≥7000’)
MA 12	Lucy’s Warbler	Late seral, low elevation riparian (<7000’)
MA 12	Yellow-breasted Chat	Late seral, low elevation riparian (<7000)
MA 12	Macroinvertebrates	Late seral, high and low elevation riparian
MA 12	Cinnamon Teal	Wetlands/aquatic

Table 3K-3
Management Indicator Species Considered But Eliminated from Detailed Analysis

Species	Habitat
Juniper (Plain) Titmouse	Late seral and snag component of pinyon-juniper
Lincoln's Sparrow	Late seral, high elevation riparian ($\geq$7000')
Lucy's Warbler	Late seral, low elevation riparian (<7000')
Yellow-breasted Chat	Late seral, low elevation riparian (<7000')
Macroinvertebrates	Late seral, high and low elevation riparian
Cinnamon Teal	Wetlands/aquatic

Pygmy Nuthatch (*Sitta pygmaea*)

The pygmy nuthatch is tied to old ponderosa pine within younger stands, stands of old-growth ponderosa trees, old large oak trees, and cavities. Populations are thought to be stable on the CNF and state-wide. Ponderosa pine snags, a key habitat component for this species, are currently being lost faster than they are replaced and may affect populations of the pygmy nuthatch in the future.[376]

Wild Turkey (*Meleagris gallopavo merriamii*)

Wild turkey is an indicator of late seral stage ponderosa pine forests, based on roost habitat requirements. Turkey roosts and nesting habitat occur in steep drainages and on hills. Turkey populations on the CNF declined in the early 1990s and have increased since the mid 1990s in probable response to favorable overwintering conditions, changes in hunt design in the game management unit, and contributions to overall mast production from trees from the 1919 seed year. The age class distribution of ponderosa pine has remained the same during Forest Plan implementation. Late seral stage trees have remained largely unchanged on slopes greater than 40 percent. The loss of large old trees occurred on slopes less than 40 percent during the early stages of Forest Plan implementation. The rate of loss due to timber harvest is now much reduced and for trees over 24 inches dbh rarely occurs. Other factors affecting turkey populations are lack of cover in key areas (including travel corridors), water availability, and forage availability are important factors.[377] Turkey habitat in the analysis area consists of ponderosa pine and mixed conifer forest with openings and small meadows for foraging during summer months. Ponderosa pine mast is the key habitat attribute and steep drainages and hillsides provide roosting and nesting habitat.

Elk (*Cervus elaphus*)

Elk are indicators of early seral stage ponderosa pine, mixed conifer, and spruce-fir forest. Grasslands are also important to elk. Elk are associated with deciduous thickets and early seral forest with interspersed grasses and forbs. They typically summer in mountain meadows and conifer forests and winter in pinyon-juniper woodlands and grasslands at lower elevations. Elk feed mainly on grasses, but will also feed on forbs and browse species. Population trends for the three main elk herds on the CNF are relatively stable, although overall numbers have been reduced since the early to mid-1990s. Despite reductions in the number of elk forest-wide since 1993, impacts to riparian areas and meadows are still substantial.

[376] USDA, 2002
[377] Id.

The analysis area provides summer range for elk and is located within Arizona Game and Fish Department's Game Management Unit (GMU) 7. This unit shows a generally increasing trend in population size since 1986.[378] Elk tend to stay in the higher elevations during the summer months, moving into lower elevation pinyon-juniper woodlands and ecotonal areas north of the Peaks after significant snowfall.[379] Within the analysis area, ecotonal areas between conifer forest and grasslands are important to elk.[380] Recreational activities such as hiking may cause disturbance to elk foraging in meadows or resting in forested or edge areas.

Hairy Woodpecker (*Picoides villosus*)

This species is an indicator of snags in ponderosa pine, mixed conifer, and spruce fir forest. Hairy woodpeckers are over-wintering cavity nesters associated with larger trees and dense forest canopy. They nest in holes in dead or dying trees and appear to be limited primarily by the availability of suitable cavity trees. The population status of this species is considered secure in Arizona. There are no population estimates on the CNF, but hairy woodpecker populations appear to be stable. The snag component in ponderosa pine forest has declined, but has increased in mixed conifer and spruce-fir forest due to wildfire and insect outbreaks/disease.[381] Hairy woodpeckers are fairly common in conifer forest types within the analysis area.

Red Squirrel (*Tamiasciurus hudsonicus mogollensis*)

The Forest Plan designates the red squirrel as a MIS for late seral stage mixed conifer and spruce-fir forests. Red squirrels are generally found at higher elevations in stands of spruce or a mixture of spruce and Douglas-fir. They are cavity nesters and feed on Engelmann spruce, Douglas-fir, white fir, fungi, buds, and fruits. They harvest the cones from trees to get to the seeds. Dwarf mistletoe creates witches broom, which may be helpful for nesting purposes. The population trend for red squirrels on the Forest is inconclusive, due to lack of information on populations. No population estimates have been made on the CNF. Some habitat loss has occurred, but snags remain abundant. The future trend towards smaller trees could affect red squirrels. Due to the importance of mast producing trees, red squirrel populations probably fluctuate due to weather and cone crops.[382]

Red-naped (Yellow-bellied) Sapsucker (*Sphyrapicus nuchalis*)

The red-naped sapsucker is a MIS for the late seral stage and snag component of aspen. Red-naped sapsuckers nest primarily in aspen, or in deciduous/mixed conifer forest, often near water. Live trees are preferred although dead trees (usually spruce or other conifers) are used at times. This species excavates a new hole each year. They extricate sap and the soft cambium layer around willows, cottonwoods, aspens, and walnuts. Nest trees are a minimum DBH of 10 inches with a minimum height of 15 feet. They favor groups of large aspens near heads of higher elevation canyons during the summer. Threats include

[378] Id.
[379] AGFD, 2003
[380] Arizona Game and Fish Department Wildlife Manager, pers. comm. 2003
[381] USDA, 2002
[382] Id.

gradual decline of mature aspen stands and mixed deciduous forests adjacent to water sources, and forest pest control efforts. Browsing by elk and other wild ungulates is curtailing recruitment and inhibiting the re-establishment of mature aspen stands on a Forest-wide basis. As a result of this reduction in aspen, red-naped sapsuckers are considered declining in this area.[383]

Mule Deer (Odocoileus hemionus)

The mule deer was selected as an MIS of early-seral stages of aspen and pinyon-juniper woodlands. Early-seral stages of ponderosa pine, mixed-conifer, and chaparral habitats are also important for this species. Mule deer are primarily browsers on green shoots and fruits of shrubs and trees, but also feed on grasses and forbs. Mule deer populations have not done well on the CNF since Forest Plan implementation, due to many factors, such as disease, poaching, climatic conditions, and habitat changes. Creation of early seral aspen and pinyon-juniper has not occurred at a sufficient scale to positively influence browse production that would benefit mule deer.[384]

Mule deer occur within Game Management Unit (GMU) 7 and there appears to be population interchange with the herd in GMU 9 on the adjacent Kaibab National Forest.[385] The highest densities of mule deer are found in previously burned areas north of the San Francisco Peaks.[386]

Pronghorn Antelope (*Antilocapra americana*)

Pronghorn antelope is the only MIS identified for mountain grassland, and grassland and sparse pinyon-juniper. Populations are declining, although not equally, on the CNF. Arizona Game and Fish Department surveys of GMUs suggest declining trends in number of observed animals in most areas of the CNF and most areas have remained below the break even point of 20 to 35 fawns per 100 does in many years. Since the implementation of the Forest Plan, the amount of grassland Forest-wide has generally remained stable, with the exception of about a four percent increase in seral grasslands due to fuelwood treatments and fire. Forest-wide habitat trend is stable to declining due to tree encroachment, fire suppression, long and short-term climate shifts, and ungulate grazing. Establishment of woodland and pine seedlings and saplings in meadows and previously treated openings decreases habitat quality.[387] A number of factors have been identified that affect pronghorn, including: severe weather; amount and timing of precipitation; long-term climatic trends; habitat fragmentation; diet overlap with other grazers; reductions in fawn hiding cover; woody vegetation encroachment; fences; human disturbance and development; water availability; predators; parasites and diseases; and nutritional concerns.

Forest-wide grassland condition trends vary from downward to upward and the overall trend is stable to declining. Cool season grasses and species diversity have increased since the 1950's in probable response to climate change and a recovery from land abuses

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[383] USDA, 2002

[384] Id.

[385] Id.

[386] AGFD, 2003

[387] USDA, 2002

near the turn of the century. Tree encroachment, increasing canopy cover, fire suppression, long-term climatic changes, drought, and ungulate grazing are mainly responsible for downward trends. GMU 7 shows the most stable population of pronghorn.[388]

Little pronghorn habitat occurs in the analysis area. Grassland areas are limited and there is no pinyon-juniper woodland. Pronghorn are not expected to use high elevation subalpine grasslands near the SUP. Montane grassland associated with Fort Valley provides very limited pronghorn habitat due to the degree of human development and fencing.

MIGRATORY BIRDS

Executive Order 13186 was signed on January 10, 2001, placing emphasis on conservation of migratory birds. This order requires that an analysis be made of the effects of Forest Service actions on Species of Concern listed by Partners in Flight, the effects on Important Bird Areas (IBAs) identified by Partners in Flight, and the effects to important overwintering areas.[389] There are no IBAs or important wintering areas within the analysis area. The closest IBA exists at Mormon Lake. The following describes each habitat type found within the analysis area and the associated bird species of concern.

Habitat Types

Alpine

Alpine habitat occupies about 20 acres above timberline in the SUP area and covers an estimated 1,600 acres on the San Francisco Peaks, generally above 11,500 feet. Only the water pipit is known to breed in this habitat type.

Spruce-fir

Four species of concern have been identified for spruce-fir habitat types: Swainson's thrush, pine grosbeak, golden-crowned kinglet, and three-toed woodpecker. Spruce-fir forest covers the majority of the SUP area, adjacent areas within the Kachina Peaks Wilderness, and the upper mile of the Snowbowl Road.

Mixed Conifer

Three species of concern have been identified for mixed conifer habitat types: northern goshawks, Mexican spotted owls, and olive-sided flycatchers. Mixed conifer forest occupies approximately 21.7 acres in the southwestern portion of the SUP. It also occurs along the upper portion of Snowbowl Road above 8,000 feet in elevation and on adjacent Forest lands.

Pine

Ponderosa pine habitat types occur along Snowbowl Road below 8,000 feet and along forested portions of the reclaimed water pipeline alignment from Fort Valley to Flagstaff.

[388] USDA, 2002

[389] Latta, et al. 1999

Four species have been identified as species of concern in pine habitats. They are northern goshawks, olive-sided flycatchers, Cordilleran flycatchers, and purple martins.

High Elevation Grassland

High elevation grassland habitat types include the upper portion of Hart Prairie in and near the SUP (subalpine grassland), Fort Valley (montane grassland) along the reclaimed water pipeline alignment. Four species have been identified as species of concern for high elevation grasslands. They are ferruginous hawks, Swainson's hawks, burrowing owls, and grasshopper sparrows.

Northern goshawk and Mexican Spotted owl are discussed in the TES section of the Wildlife section. Table 3K-4 lists migratory bird species considered, but not taken through detailed analysis because no habitat occurs and/or the analysis is outside the geographic range of the species.

Species

Water Pipit (*Anthus spinoletta alticola*)

The water pipit breeds above timberline in the San Francisco Peaks and White Mountains of northern and eastern Arizona.[390] The water pipit is one of only two vertebrate species known to breed in Alpine Tundra habitats in the state. Recreation is the greatest potential threat to habitat for this species.[391]

Swainson's Thrush (*Catharus ustulatus*)

Swainson's thrush is described as a rare summer resident in the cork-bark fir forest of the San Francisco Peaks and the White Mountains. At times it may be locally common. Important habitat components in fir forest are dense herbaceous and shrub vegetation, multiple forest layers, and downed logs.[392] Management recommendations for this species include incorporating of irregular thinning, leaving random clumps of dense saplings or vegetation in the lower or middle forest layers.[393]

Pine Grosbeak (*Pinicola enucleator*)

Pine grosbeaks are uncommon permanent residents of high elevation conifer forests in the White Mountains. This species prefers stands of spruce-fir with large trees and intermediate canopy cover, near edges. They forage both in trees and in open grass areas on seeds, buds, mast, and insects. Pine grosbeaks flock outside the breeding season, preferably in juniper habitats. Pine grosbeaks are not known to breed on the San Francisco Peaks, although there are a few reports of wintering flocks.[394] Species-specific surveys conducted during the breeding season in 1995 failed to detect any pine

[390] Monson and Phillips, 1981
[391] Latta et al., 1999
[392] Monson and Phillips, 1981 and Latta, 1999
[393] Latta et al., 1999
[394] Monson and Phillips, 1981 and Latta, 1999

grosbeaks.[395] Management recommendations for this species are no large-scale removal of overstory Engelmann spruce and promotion of activities that reduce fire risk.[396]

Table 3K-4
Migratory Bird Species Considered But Eliminated from Detailed Analysis

Species	Habitat/Elimination Rationale
Swainson's Hawk	High Elevation Grassland. Not known to occur regularly in higher elevation montane and subalpine grasslands.
Burrowing Owl	High Elevation Grassland. Not known to occur regularly in higher elevation montane and subalpine grasslands.
Grasshopper Sparrow	High Elevation Grassland. Breeding range generally restricted to southeastern Arizona and at lower elevations.
Gray Flycatcher	Pinyon-juniper
Pinyon Jay	Pinyon-juniper
Gray Vireo	Pinyon-juniper
Black-throated Gray Warbler	Pinyon-juniper
Juniper Titmouse	Pinyon-juniper
Elegant Trogon	High Elevation Riparian
McGillivray's Warbler	High Elevation Riparian
Red-Faced Warbler	High Elevation Riparian

Golden-crowned Kinglet (*Regulus satrapa*)

In Arizona, golden-crowned kinglets breed in spruce-fir, mixed conifer, deciduous and single species stands in mountainous areas from the Kaibab Plateau eastward. They prefer to nest in dense stands of conifers, often near the edges of clearings. Nesting stands have both open and closed canopy and density of understory vegetation is not thought to be important. Management recommendations are to avoid large-scale removal of overstory and larger trees, manage forests to reduce fire risk, and minimize recreational activity around breeding sites in April through June.[397]

Three-toed Woodpecker (*Picoides tridactylus*)

Three-toed woodpeckers breed and forage preferentially in spruce-fir forest, particularly where insect populations are high due to tree disease of fire. They are also found in ponderosa pine and Douglas-fir forests. This woodpecker plays an important role in the control of bark beetles, which may comprise up to 65 percent of its diet. It is thought to be the only woodpecker capable of excavating cavities in the dense wood of living spruce trees. Three-toed woodpeckers typically nest in dead or dying trees, showing a preference for trees with 75 percent of the bark and 10-80 percent of the limbs remaining, but no dead needles left on branches. Snags dead for less than three years are thought to be an important habitat component. Management recommendations include retention of snags greater than 12 inches DBH for nesting and trees averaging 25 inches DBH for

[395] SWCA, 1996b
[396] Latta et al., 1999
[397] Latta et al., 1999

foraging, maintenance of 75-acre minimum patches of diseased trees for foraging, and limiting salvage logging after insect kills in spruce-fir forest.[398]

Olive-sided Flycatcher (*Contopus borealis*)

Olive-sided flycatchers prefer forest edges and natural or human-made openings in spruce-fir, mixed conifer, and ponderosa pine forest types. They nest high in coniferous trees and forage primarily on flying insects. Management recommendations include maintenance or creation of openings, management for uneven-aged forest structure, and retention of tall snags or dead-topped trees during salvage operations.[399]

Cordilleran Flycatcher (*Empidonax occidentalis*)

Cordilleran flycatchers breed predominantly in pine, but also in spruce, fir, aspen forests. They prefer moist and shaded forest. This species is a facultative secondary cavity-nester that also uses rock crevices, tree roots, and forks in small branches. Numbers of birds have been found to be positively correlated with canopy cover, within stand variability of trees sizes (most abundant in stands with five to 20 percent of pine basal area comprised of one to five inch DBH stems), and snag density. Management recommendations target their preferred habitat, ponderosa pine forest. They include management for greater than or equal to two snags per acre, manage for greater than 383 ponderosa pine/acre with high variability in size classes, and avoid mechanical thinning of canopy and snags.[400]

Purple Martin (*Progne subis*)

In Arizona pine forests, purple martins prefer areas with high snag density adjacent to or in open areas. They are secondary cavity nesters and forage primarily on flying insects. Management recommendations include the creation and retention of large snags.[401]

Ferruginous Hawk (*Buteo regalis*)

Ferruginous hawks historically nested in open scrublands, woodlands, and grasslands in southeastern and northern Arizona. The current distribution of breeding birds in restricted to Plains and Great Basin Grasslands in northern and northeastern Arizona. Ferruginous hawks range more widely in winter and are found throughout the state, often in agricultural areas and other open habitats.[402] Ferruginous hawks forage regularly in montane grasslands in the Flagstaff vicinity and have been observed hunting prairie dogs in the upper portion Hart Prairie within the SUP area. Management recommendations include the reduction of chemical control of prairie dogs, particularly in suitable nesting habitat and treatment to control exotic species encroachment of grasslands.

GAME AND NON-GAME WILDLIFE

The analysis area is located within Game Management Unit (GMU) 7. Large game species managed by the Arizona Game and Fish Department are the pronghorn antelope,

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[398] Id.
[399] Latta et al., 1999
[400] Id.
[401] Id.
[402] Monson and Phillips, 1981; Glinski, 1998; Latta et al., 1999

black bear, elk, mule deer, and wild turkey. Mountain lions are also known to occur in the analysis area. A number of smaller game animals and fur bearers also occur, including Abert and red squirrel, gray-collared chipmunk, mantled ground squirrel, Gunnison's prairie dog, coyote, and bobcat. Several species of bats have been documented in the Fort Valley area, west of the Snowbowl Road. The analysis area supports habitat for a number of neotropical migrant and resident breeding birds. Bird species observed in the SUP area include band-tailed pigeon, broad-tailed hummingbird, northern flicker, hairy woodpecker, northern three-toed woodpecker, Steller's jay, clark's nutcracker, common raven, mountain chickadee, red-breasted nuthatch, white-breasted nuthatch, pygmy nuthatch, house wren, golden-crowned kinglet, American robin, yellow-rumped warbler, chipping sparrow, vesper sparrow, dark-eyed junco, western tanager, and pine siskin.

ENVIRONMENTAL CONSEQUENCES

SUMMARY OF ENVIRONMENTAL CONSEQUENCES AND CONCLUSIONS

Major conclusions and determinations of this Wildlife analysis are summarized below. A more detailed analysis of the direct and indirect environmental consequences – from which this summary was derived – follows.

Alternative 1 – No Action

In conclusion, Alternative 1 would result in no changes to existing ski area operations or to forest management activities within the SUP area. As a result, there would be no effects to wildlife TES or MIS. Additionally, there would be no effects to migratory birds as a result of Alternative 1.

Alternative 2 – The Proposed Action

Alternative 2 would have no effect on threatened or endangered species within the analysis area. Regarding sensitive species, this alternative may impact individuals of the Navajo Mexican vole and habitat for the northern goshawk but is not likely to result in a trend toward Federal listing or loss of viability.

The importance of trees to be removed to MIS is limited by their relatively small size and young age, and their location adjacent to roadways and cleared utility easements. Based on these factors, tree removal would not substantially affect habitat for the Abert squirrel, pygmy nuthatch, wild turkey, elk, hairy woodpecker, red squirrel, red-naped sapsucker, or pronghorn antelope. Under Alternative 2, some species of migratory birds may be affected by tree removal, construction, and increased recreation use.

Overall, some game and non-game species would experience both positive and negative effects as a result of the Proposed Action. These potential effects would be primarily the result of additional moisture and nutrients from snowmaking, noise, and recreation activities within the SUP area, and forest fragmentation due to tree clearing for proposed developed ski terrain.

Alternative 3

Alternative 3 would have no effect on threatened or endangered species within the analysis area. Regarding sensitive species, this alternative may impact individuals of the Navajo Mexican vole and habitat for the northern goshawk but is not likely to result in a trend toward Federal listing or loss of viability.

This alternative would not affect habitat for management indicator species along Snowbowl Road or the reclaimed water pipeline alignment. Habitat modifying activities within the SUP area would not affect habitat for management indicators species outside of the SUP area.

Effects of this alternative on the water pipit, Swainson's thrush, three-toed woodpecker, cordilleran flycatcher, purple martin, and ferruginous hawk would be the same as those described under Alternative 2 (Proposed Action). Effects on pine grosbeaks, golden-crowned kinglets, and olive-sided flycatchers would be similar to the Proposed Action, except that there would be no increase in arthropod prey base related to snowmaking.

Effects to game and non-game species as described above would be similar to those disclosed under Alternative 1, with the exception of the effects of recreational use of the summer trail and increased fragmentation or loss of forested habitat on birds and large carnivores, which would be the same as those described under the Proposed Action.

DETAILED ANALYSIS OF DIRECT AND INDIRECT EFFECTS

Terrestrial Species Habitat

Issue:

***The Proposed Action may result in the alteration and/or removal of habitat for terrestrial wildlife species within the SUP* area.**

Indicator:

Disclosure/Quantification of Anticipated Effects to Threatened, Endangered, and Sensitive; Management Indicator Species, and Other Wildlife Species and Habitats Within the Analysis Area.

Alternative 1 – No Action

Threatened, Endangered, and Sensitive Species

Habitat conditions for wildlife would remain in their current condition, not withstanding natural processes. The CNF would continue existing treatment of spruce-fir stands in the SUP infected by spruce bark beetles. This alternative would have no effect on any threatened, endangered, or sensitive species.

Additional disclosure of the effects of historic ski area activities on threatened, endangered and sensitive species can be found in the Cumulative Effects analysis.

Management Indicator Species

Habitat conditions for wildlife would remain in their current condition, not withstanding natural processes. This alternative would have no effect on management indicator species.

Additional disclosure of the effects of historic ski area activities on MIS species can be found in the Cumulative Effects analysis.

Migratory Birds

Under this alternative, there would be no changes in the analysis area. Habitat conditions for birds would generally remain the same, not withstanding natural processes. This alternative would have no effect on migratory birds.

Additional disclosure of the effects of historic ski area activities on migratory birds can be found in the Cumulative Effects analysis.

Game and Non-Game Wildlife

Under this alternative, there would be no changes in the analysis area. Habitat conditions for wildlife would remain in their current condition, not withstanding natural processes. This alternative would have no effect on game and non-game wildlife.

Additional disclosure of the effects of historic ski area activities on game and non-game wildlife can be found in the Cumulative Effects analysis.

Alternative 2 – The Proposed Action

Threatened, Endangered, and Sensitive Species

As further detailed within the Biological Assessment prepared for the project, the Proposed Action would have "No Effect" on the threatened Mexican spotted owl or its habitat. There would be no tree removal in Restricted Areas or PACs and all construction activities within ½-mile of active nest sites would be restricted to periods outside the breeding season, which extends from March 1 to August 31. Helicopter over flights would be restricted around PACs. Helicopter use and other construction noise within the SUP would not affect PACs in the analysis area. These restrictions have been specifically detailed in the required mitigation measures listed in Chapter 2.

The Proposed Action would have "No Effect" on the threatened bald eagle or its habitat. Bald eagles are unlikely to be found in the SUP area. Construction activities along the proposed reclaimed water pipeline may result in eagles avoiding construction zones, although construction would predominantly take place outside the period when wintering eagles are present. Construction activities and removal of trees along the reclaimed water pipeline alignment would not affect any known winter or summer roosts and would not affect foraging or perching opportunities for bald eagles.

The Proposed Action would have "No Effect" on the endangered black-footed ferret or its habitat. This alternative would result in the temporary disturbance of approximately 17 acres and permanent disturbance of less than ½ acre of the active Gunnison's prairie dog colony within the SUP area. This disturbance is associated with the development of the snowplay area and associated facilities, relocation/realignment of the Aspen and Hart Prairie chairlifts, and the recontouring of the lower end of the *Hart Prairie* (trail #3). Prior surveys have found no black-footed ferrets in this area and the prairie dog town and associated complex are too small to provide potential habitat for this species.

The Proposed Action may impact individual Navajo Mountain Mexican voles (a Forest Service sensitive species), but is not likely to result in a trend toward federal listing or loss of viability of the species. Nine of the 13 locations where evidence of voles has been found would be temporarily disturbed by recontouring, rock/stump removal, or widening of existing ski trails. The number of individual voles potentially affected is not known. Recolonization of temporary disturbance areas would likely occur. Widening of existing ski trails and clearing of new trails would create more potential habitat for this species. Snowmaking would increase grass and forb density and cover on ski trails and could result in a local increase in the population of Navajo Mountain Mexican voles.

The Proposed Action may affect habitat for the northern goshawk, but is not likely to result in a trend toward federal listing or loss of viability. An estimated 54 pine trees would be removed in the Mars Hill PFA. The largest tree to be removed is approximately 18 inches DBH. All of these trees are adjacent to existing forest roads. Four of these trees would be removed from CNF lands; the remaining 50 would be removed from private land. Construction activities associated with installation of the reclaimed water pipeline would not affect nesting northern goshawks. Timing restrictions on construction activities within the Snowbowl PAC would largely prevent potential effects on nesting northern goshawks in the Veit Spring PFA. These restrictions would be extended to September 30 within ½-mile of any active nest site (i.e., no construction from March 1 to September 30) in the Veit Spring PFA to avoid impacts to nesting northern goshawks. Construction related traffic is not expected to affect northern goshawks nesting within this PFA. Northern goshawks using the Veit Spring PFA are likely habituated to traffic on Snowbowl Road. Timing restrictions on construction activities within ½-mile of any active nest site within the Mars Hill PFA (i.e., no construction from March 1 to September 30) would prevent disturbance to nesting northern goshawks.

As stated previously, there is no habitat in the analysis area for the Region 3 Forest Service sensitive peregrine falcon.

Management Indicator Species

The Proposed Action would result in the removal of approximately 156 trees (134 pine and 22 aspen trees) along the Snowbowl Road and the reclaimed water pipeline alignment. All trees are immediately adjacent to roadways and previously cleared utility easements. Trees that would be removed are generally eight to 10 inches DBH; the largest tree removed would be about 18 inches DBH. Fifty-two of the 136 trees are located along Snowbowl Road. No snags or old-growth trees would be removed. Neither late seral stage aspen nor its associated snag component would be affected. Trees to be removed occur sporadically along Snowbowl Road and the remainder of the reclaimed water pipeline alignment. Therefore, their removal would not affect overall stand characteristics.

The importance of trees to be removed to management indicator species is limited by their relatively small size and young age, and their location adjacent to existing roadways and cleared utility easements. Based on these factors, tree removal would not substantially affect habitat for the Abert squirrel, pygmy nuthatch, wild turkey, elk, hairy woodpecker, red squirrel, red-naped sapsucker, or pronghorn antelope.

This alternative would disturb some potential foraging habitat for mule deer. Tree removal along Snowbowl Road and the proposed reclaimed water pipeline alignment would include the removal of 22 smaller-sized aspen trees, some of which may provide browse for deer. Construction of the reclaimed water pipeline would result the temporary removal of forbs, shrubs, and other potential forage species along Snowbowl Road and the remainder of the water pipeline alignment.

Habitat modifying activities within the SUP area (overstory spruce-fir removal to create new ski trails, thinning of stands to treat a spruce bark beetle infestation, and developed uses) would not affect habitat for management indicators species outside of the SUP area.

Migratory Birds

Effects of this alternative on migratory birds would occur primarily within the SUP area. Effects of tree removal along Snowbowl Road and the reclaimed water pipeline alignment on migratory birds would be negligible because these activities would involve a relatively small number of younger trees located at the edges of previously cleared areas, such as roadways and utility easements, and therefore provide limited resources for wildlife. Within the SUP area, proposed activities may affect these species directly through habitat removal or modification, or indirectly through changes in prey populations. Effects of noise, recreational activities, and habitat fragmentation on birds in general are discussed in the Game and Non-game Wildlife section below.

This alternative would have little effect on breeding habitat for the water pipit. Approximately ½-acre of alpine tundra would be disturbed to increase the landing area at the top at the Agassiz chairlift top terminal. This area consists of a steep and rocky talus slope that supports little vegetation. The potential suitability of this area for nesting pipits is already diminished by ongoing recreational activity associated with operation of the Scenic Sky Ride.

This alternative may affect the Swainson's thrush. This alternative would remove 76.3 acres of spruce-fir forest, representing potential habitat, within the SUP area for the construction of new ski trails and other improvements. Thinning of 47.4 acres of spruce-fir to address a localized spruce bark beetle outbreak would improve habitat conditions for the Swainson's thrush by creating a greater diversity of vegetation age classes and openings for the growth of grasses, forbs, shrubs, and tree saplings. Establishment and use of the summer hiking trail in this area would reduce habitat suitability for potentially breeding thrushes because of disturbance from human recreational activity.

The Proposed Action would have both negative and positive effects on habitat for pine grosbeaks and golden-crowned kinglets. Negative effects are related to the removal of overstory vegetation and disturbance from recreational use of the summer trail. Positive effects would be the creation of additional edge habitat, an increase in biomass of vegetation, and increased arthropod prey on cleared ski trails.

Thinning of 47.4 acres of spruce-fir forest within the Agassiz and Sunset skiing pods would negatively affect the three-toed woodpecker by reducing preferred prey populations (spruce bark beetles) and by removing larger trees and snags that may serve as potential nesting habitat. Due to the pervasiveness of wildfire and bark beetle infestation on both a local and regional scale, activities under this alternative would not affect the overall population viability of this species.

The Proposed Action would improve habitat for olive-sided flycatcher by creating additional openings and enhancing arthropod prey populations due to snowmaking activities.

This alternative would have little effect on habitat for the cordilleran flycatcher and the purple martin. These species occur primarily in ponderosa pine forest. Effects on this vegetation type would be limited to tree removal along Snowbowl Road and the reclaimed water pipeline.

This alternative would have a negative effect on the ferruginous hawk through the disturbance of the prairie dog colony at the upper reach of the Hart Prairie within the SUP area. Proposed activities there would reduce prey availability for wintering or migrating hawks, but they would not affect breeding individuals. Since prairie dogs would likely recolonize the disturbed areas, effects on prey base for ferruginous hawks would be temporary in nature.

Game and Non-Game Wildlife

This alternative would have positive effects on some game and non-game wildlife species, and negative effects on others. Effects of tree removal along Snowbowl Road and the reclaimed water pipeline alignment would be negligible because these activities would involve a relatively small number of younger trees located at the edges of previously cleared areas, such as roadways and utility easements, and therefore provide limited resources for wildlife. This analysis therefore focuses on potential effects of proposed activities on wildlife in the SUP area and in the adjoining Kachina Peaks Wilderness. These include the potential effects of (1) additional moisture and nutrients from snowmaking on plants as a source of food for wildlife, (2) noise and recreational activities on wildlife use patterns, and (3) habitat removal and fragmentation on habitat suitability.

Increased Moisture and Nutrients

The effects of snowmaking and additional nitrogen loading on plants are discussed in detail under the Vegetation section of this chapter. In general, additional moisture and nutrients would favor early successional and weedy species which may reduce overall plant species diversity, and could result in limited tree mortality along the edges of ski trails. Based on patterns of surface and groundwater hydrology, these effects would be largely limited to the areas directly affected by snowmaking (i.e., the cleared ski trails). These areas currently support a predominantly non-native plant community consisting of commercially seeded grasses and forbs. Almost all of the seeded species are also early successional species, and their cover and biomass would therefore increase with added moisture and nutrients. Greater dominance of early successional plant species as a result of wastewater enrichment has been correlated with increased arthropod density and diversity in pine forest and short-grass prairie habitats. It is postulated that C3 plants (which include virtually all seed mix species) are more palatable or digestible for generalist herbivores.[403] Increased biomass of plants on cleared ski trails would therefore directly benefit larger herbivores, such as elk and mule deer, and would directly or indirectly benefit granivorous and insectivorous birds through greater seed and invertebrate prey production, respectively. Reduced plant species diversity would reduce habitat quality for wildlife that specialize on particular native plant species.

Noise

Construction noise within the SUP area and along Snowbowl Road and the reclaimed water pipeline alignment may affect some wildlife species. Noise would result primarily from the operation of equipment for clearing, grading, and smoothing of ski trails and installation of the snowmaking water pipeline; construction of new lift lines and realignment of existing lift lines, including the use of a helicopter for setting lift towers; improvement of existing guest service and maintenance facilities and utilities; and construction of the reclaimed water pipeline. These activities would generally take place during late spring, summer, and early fall and would coincide with, or overlap, the breeding period for many wildlife species. Wildlife most likely affected would be those whose breeding habitat overlaps the analysis area (i.e., primarily birds and small mammals) or wildlife who use the area for foraging and/or resting (elk and mule deer). Over the long term, these effects would be temporary in nature and would be limited to the construction phase of the improvements. Over the short term, these types of effects may occur over a number of consecutive years, representing the implementation phase of the project.

Construction activities would likely result in some disruption of wildlife breeding and foraging activities in and around the work areas. Studies on both diurnal and nocturnal raptors have documented few responses to noise (including helicopters and blasting) and few adverse effects on nesting success beyond 400 m (¼-mile). Maximum noise levels at this distance would not exceed 65 dBA and would be well below threshold levels at which responses in raptors have been documented (±90 dBA or greater). Assuming that responses of raptors are representative, construction noise may interrupt breeding and foraging activities of birds and small mammals up to about ¼-mile from work areas. It would also preclude or reduce foraging, movement, and/or resting behavior of larger wildlife, such as deer and elk, in the area. At a maximum, this would affect the entire SUP area and up to a ¼-mile zone of influence in the adjacent Kachina Peaks Wilderness and adjacent Forest, private, and Arizona Game and Fish Lands along Snowbowl Road and the reclaimed water pipeline alignment. A number of species of birds and small mammals are likely more tolerant of noise than the larger raptor species. Wildlife in the analysis area have likely habituated to noise to some degree due to regular traffic on Snowbowl Road, year-round recreational and maintenance activities in the SUP, and recreational activity (hiking) along the Humphreys Trail. Since construction would occur in phases, only a portion of the analysis area would be affected in any one year. Also,

[403] Hunt and Shure, 1980; Kirchner, 1977

construction activities would be limited in duration and would not extend over the entire breeding season for birds or small mammals. In most cases, adjacent undisturbed habitats would become suitable for wildlife after completion of construction activities. Since construction activities would be limited to daylight hours, movement and foraging activities of deer and elk would not be affected during the nighttime hours. In contrast to improvements within the SUP area, construction of the reclaimed water pipeline from Flagstaff would likely take place over the course of one summer construction season.

Additional noise in the analysis area from operation of the snowmaking system (pumping facilities and snowmaking guns) and increased use of snowcats would have limited effects on wildlife. Within the SUP area, these activities would take place during nighttime hours, outside the breeding periods for most, if not all wildlife species, and would result in relatively low and sustained noise levels. Snowmaking and associated snowcat use would take place during nighttime hours in winter. Noise output from snowmaking guns is estimated at 84 dBA at 15 m (30 feet) from the source. Noise from the pump stations would be inaudible at approximately 30 m (100 feet) from the source. Snowcat use occurring within the SUP area would not change substantially from the existing condition. These activities may continue to affect roosting birds or other wildlife that remain in the SUP year-round and which occur in the direct vicinity of the activities. However, due to the high metabolic demands at high elevations and cold temperatures, relatively few birds or other wildlife species likely remain in the SUP overnight during the winter period.

Recreation

Increased recreational activity may result in disturbance of some game and non-game wildlife. Proposed improvements would not increase the average number of skiers per day in the SUP area, but would introduce snowplay activity and potentially extend the period when recreationists are present during winter affecting the distribution of recreational use in the winter. Snowmaking under this alternative would extend the ski season in winter, which currently has a short or highly variable duration in some years. Extended and increased recreation use relative to current conditions would occur during the winter period, outside the breeding season for most, if not all, wildlife species. Day-time activities associated with skiing may interrupt foraging activities of some bird species, such as nuthatches and woodpeckers, and may result in increased stress levels and metabolic demands. These effects would be extended over a longer average period during the winter. They would affect birds foraging in the vicinity of the existing ski trails and the proposed 73.7 acres of new ski trails in the SUP area. Increased recreational activity in the SUP area may result in greater abundance of nest scavengers, such as crows, ravens, and Steller's jays (corvids) and higher rates of nest predation.[404]

The proposed summer hiking trail would affect wildlife by changing recreational use patterns within the SUP area. The proposed trail would provide a pedestrian route through the SUP area for Scenic Sky Ride users in summer. This trail would switchback through a stand of spruce-fir forest between the Agassiz Chairlift top terminal and the mid-station and would subsequently follow and existing unimproved access road to the base of the ski area. Use of this trail by hikers would result in some disturbance to

[404] Marzluff, 1997

wildlife. Repeated human intrusions in songbird territories can decrease singing, change nest defense behavior, increase predation, and result in local declines of songbirds.[405] Outdoor recreational activities such as hiking can result in energetic costs, impacts to behavior and fitness, and avoidance of otherwise suitable habitat. In open grassland habitat in Utah, mule deer generally took flight when hikers on established trails approached within 100 m (±300 feet) in perpendicular distance, although these effects would be less in forested areas with substantially more cover.[406] Assuming a 100 m (±300 feet) zone of influence on both sides of the ±two mile pedestrian route (one mile of new trail, one mile existing unimproved road), recreational use of the summer trail would reduce the habitat suitability for wildlife by up to 15 acres within the SUP area.

Forest Fragmentation

Fragmentation of forested habitat within the SUP area may affect some wildlife species. Habitat loss coupled with fragmentation of remaining habitats is cited as the cause of declines in forest bird species through loss of breeding areas, detrimental edge effects such as increased nest predation and brood parasitism, and limitations on movement between habitat patches.[407] A number of studies have reported a direct correlation between habitat patch size and the density, diversity, and reproductive success of forest birds. A number of these studies were based on woodlots of various sizes within cleared agricultural fields in the eastern North America.[408] Results of studies from other areas and habitat types are more variable. A study found that predation rates were higher in forested landscapes compared with habitats fragmented by agriculture, presumably due to higher abundance of predatory red squirrels.[409] These researchers also found that corvids (jays, crows, ravens) increased only at very high levels of habitat fragmentation. Another review of 25 studies on the relationship between habitat patch size and population density for birds, mammals, and insects throughout the world. Based on their results, these researchers concluded that (1) generalist species are affected only by direct habitat loss, (2) interior species would be affected more by fragmentation than edge species, unless only small patches are removed from the landscape, and (3) resident interior species are most vulnerable, while migrant edge species are least vulnerable to the effects of fragmentation.[410]

This alternative would result in additional fragmentation of the remaining forested habitat within the SUP area. A total of 76.3 acres of overstory spruce-fir forest would be removed to create new ski trails. Most of this would be associated with development of the new Humphreys pod in the north central portion of the SUP area. This activity would open up a stand that currently has more or less continuous forested cover. This ski trail would be designed with a network of small forested islands to create a less continuous break in the landscape. Most of these patches are small in size and would potentially be subject to higher predation risk from corvids, reducing and potentially eliminating their suitability for nesting birds. This activity may also result in higher nest predation rates at

[405] Id.
[406] Taylor and Knight, 2003
[407] Beslisle et al., 2001
[408] Wilcove, 1985; Weinberg and Roth, 1998; Burke and Nol, 2000; Doherty and Grubb, 2001
[409] Tewksbury et al., 1998
[410] Bender et al., 1998

the periphery of the cleared ski trail. Based on a 100 m (±300 feet) zone of influence, these edge effects may extend up to a distance of 75 m into the Kachina Peaks Wilderness at the north end of this proposed new ski trail. Although removal of overstory vegetation would increase the risk of predation by corvids, it would decrease predation rates by red squirrels.

Removal of overstory vegetation may potentially affect larger and more wide-ranging mammals, such as mountain lions and black bears. Clearing of new ski trails would further reduce hiding cover within the SUP area for large carnivores potentially traveling through the area. Although movement may be restricted, it is unlikely that movement of these animals through the SUP area would be precluded. Retention of small forested islands would mitigate the reduction of hiding cover along the proposed new Humphreys pod. Mountain lions and black bear are most likely to travel at night and are unlikely to use the SUP area regularly in winter months. Both species are known to travel through or near areas with various levels of human development.[411] Increased recreational use and upgraded guest service facilities within the SUP area may result in a greater frequency of encounters between humans and bears, particularly in drought years.[412]

Alternative 3

Threatened, Endangered, and Sensitive Species

As detailed discussion of the potential affects to threatened and endangered species is contained within the Biological Assessment prepared for the project.

This alternative would have no effect on the Mexican spotted owl or its habitat. Construction activities within the SUP area would not affect Mexican spotted owls.

This alternative would have no effect on the bald eagle or its habitat.

This alternative would have no effect on the black-footed ferret or its habitat. Like the Proposed Action, this alternative would result in the temporary disturbance of approximately 17 acres of the active Gunnison's prairie dog colony within the SUP area. This disturbance would be due solely to recontouring of the lower end of the *Hart Prairie* (trail #3), and the relocation/realignment of the Aspen and Hart Prairie chairlifts. No black-footed ferrets have been found in this area and the prairie dog colony is too small to provide potential habitat for this species.

The effects of this alternative on the Navajo Mountain Mexican vole would be the same as described under the Proposed Action, except that existing grass and forb densities would not increase due to seasonal snowmaking.

The effects of this alternative on the northern goshawk would be the same as described under the No Action Alternative, except that there would be an increase in traffic on Snowbowl Road through the Veit Spring PFA due to construction activities in the SUP. Construction-related traffic along Snowbowl Road is not expected to impact nesting in this PFA.

[411] Foster and Humphrey, 1995; Zack et al., 2003; Clevenger and Waltho, 2000

[412] Zack, et al., 2003; Arizona Game and Fish Department, 2003

Management Indicator Species

This alternative would not affect habitat for management indicator species along Snowbowl Road or the reclaimed water pipeline alignment. Habitat modifying activities within the SUP area would not affect habitat for management indicators species outside of the SUP area.

Migratory Birds

Effects of this alternative on the water pipit, Swainson' thrush, three-toed woodpecker, cordilleran flycatcher, purple martin, and ferruginous hawk would be the same as those described under Alternative 2 (Proposed Action). Effects on pine grosbeaks, golden-crowned kinglets, and olive-sided flycatchers would be similar to the Proposed Action, except that there would be no increase in arthropod prey base related to snowmaking.

Game and Non-Game Wildlife

Under this alternative, there would be no removal of trees along Snowbowl Road or the reclaimed water pipeline alignment. There would be no increase in biomass of vegetation or arthropods related to additional moisture and nutrients from snowmaking. Overall construction noise would be less due to the elimination of the snowmaking system, its associated pipeline, and the snowplay facilities. There would be no additional noise in the SUP area from snowgun and pump station operation. Operation of snowcats and recreational use by skiers would likely occur over a shorter ski season, on average, resulting in fewer potential impacts on wildlife. The effects of recreational use of the summer trail and increased fragmentation or loss of forested habitat on birds and large carnivores would be the same as those described under the Proposed Action (Alternative 2).

Longer Duration Snowpack

Issue:

Effects of a longer-duration snowpack, and water storage on wildlife within the SUP area.

Indicator:

Acreage of Proposed Snowmaking Coverage, Comparison of Natural Snowpack Duration With the Extended Snowpack Due to Snowmaking, and the Effects of Both Longer-Duration Snowpack and Water Storage (Impoundment) on Wildlife.

Alternative 1 – No Action

Under this alternative, there would be no snowmaking or associated water impoundment in the SUP area. Habitat conditions for wildlife, including threatened, endangered, and sensitive species; management indicator species; migratory birds; and game and non-game wildlife would remain in their current condition, not withstanding natural processes.

Alternative 2 – The Proposed Action

Proposed snowmaking under this alternative would cover approximately 205 acres within the SUP area. Snowmaking would generally extend the duration of snowpack in the SUP area. Snow grain (crystal) size of machine-produced snow is typically smaller than that of natural snow. This would result in denser snow that typically takes longer to melt than natural snow. Observational studies in Colorado have indicated that artificial snowpack persists about two weeks longer than natural snowpack, although this is dependent on physical factors, such as aspect and slope.[413]

A 10-million gallon water impoundment reservoir would be constructed within the SUP area to provide storage for snowmaking operations. This impoundment would receive water from the City of Flagstaff, via the reclaimed water pipeline, through the end of February of each year. This reservoir would remain at least partially filled outside the ski season to protect the integrity of the impoundment lining and to provide an emergency water source. This impoundment would be surrounded by an 8-foot high chainlink fence to exclude wildlife. Fencing would incorporate orange netting to reduce the potential for bird collisions.

Threatened, Endangered, and Sensitive Species

The Proposed Action would have no effect on any threatened or endangered wildlife species, but may affect some sensitive wildlife species. Bald eagles, black-footed ferrets, Mexican spotted owls, and peregrine falcons either do not occur or don't occur regularly in the SUP area and would therefore be unaffected by either the longer duration snowpack or the water impoundment. Northern goshawks have been observed foraging occassionally in the SUP area including the vicinity of the proposed water impoundment. Fencing of the impoundment would exclude larger wildlife, but the presence of surface water would attract birds. Northern goshawks occassionally foraging in the area may respond to the increased concentration of potential prey around the impoundment. Orange netting incorporated into the fencing would reduce, but not completely eliminate the potential for northern goshawk collisions with the fence. Extended snowpack duration would not affect the Navajo Mountain Mexican vole, other than potentially improving the forage base.

Management Indicator Species

The effects of the extended snowpack duration and the snowmaking water impoundment are limited to the SUP area. Because the SUP area is managed as a developed recreational site, impacts to MIS are not analyzed. However, effects on some of these species are addressed in the Game and Non-game Wildlife section below.

Migratory Birds

Extended snowpack duration and the snowmaking water impoundment would have no effect on the water pipit, Swainson's thrush, or the three-toed woodpecker. Pine grosbeaks, golden-crowned kinglets, olive-sided flycatchers, and cordilleran flycatchers

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[413] Williams, 2003

may benefit from enhanced arthropod prey populations due to extended moisture availability. Purple martins may benefit from the water impoundment as an additional surface water source and an area of higher arthropod prey densities. These benefits may be offset by increased potential for collisions with the fence surrounding the impoundment. Extended moisture availability would enhance the growth of grasses and forbs in the upper portion of Hart Prairie, increasing forage availability for prairie dogs. This in turn may benefit ferruginous hawks foraging in this area.

Game and Non-Game Wildlife

Greater moisture availability from snowmaking and an extended snowpack would generally enhance the growth of grasses and forbs on cleared ski trails within the SUP area. This would locally increase forage conditions for deer and elk and result in higher densities of these game species in the SUP area. The snowmaking water impoundment would have no effect on most game and non-game wildlife because access would be excluded by fencing. These species would continue to rely on natural surface water sources, in addition to waters (stock tanks) that have been placed specifically for wildlife in the SUP area. Some game and non-game birds would benefit from this additional surface water source offered by the snowmaking impoundment. Orange netting incorporated into the fencing would reduce, but not completely eliminate the potential for bird collisions with the fence.

Alternative 3

The effects of this alternative on threatened, endangered, and sensitive species; management indicator species; migratory birds; and game and non-game wildlife would be the same as those described under the Alternative 1 (No Action).

CUMULATIVE EFFECTS

Scope of Analysis

Temporal Bounds

The temporal bounds of the cumulative effects analysis for wildlife extend from the initial development of Snowbowl as a winter recreational area into the foreseeable future during which recreation-related activities may affect wildlife.

Spatial Bounds

The physical extent of this cumulative effects analysis comprises mainly the Snowbowl SUP area, the proposed reclaimed water pipeline alignment between the City of Flagstaff and the SUP area, and adjacent public lands to the extent they would be potentially affected. These adjacent lands include a portion of the Kachina Peaks Wilderness Area, areas adjacent to the reclaimed water pipeline alignment, and areas downslope of the SUP area (primarily Hart Prairie). Other projects in the Peaks area that affect wildlife are also included in the cumulative effects analysis.

Past, Present, and Reasonably Foreseeable Future Actions

1. Kachina Peaks Wilderness Area Designation
2. White Vulcan Mine Settlement and Reclamation
3. San Francisco Mountain Mineral Withdrawal
4. Development and Maintenance of the SUP as a Recreational Area
5. Spruce Bark Beetle Control within the SUP
6. Fort Valley Restoration Project
7. Transwestern Lateral Pipeline Project
8. Peaks Segment of the Arizona Trail
9. Private Land Development
10. Miscellaneous/ongoing Recreational Uses
11. Power Line Maintenance
12. Various Aspen Regeneration and Exclosure Fences
13. Inner Basin Waterline Pipeline Maintenance
14. Snowbowl Road Paving

Appendix C includes the full list of past, present and reasonably foreseeable future actions analyzed in this document, as well as background information on each of them.

Alternative 1 – No Action

Threatened, Endangered, and Sensitive Species

Past development of the SUP area as a winter recreational area, associated maintenance activities, and measures implemented to control a spruce bark beetle outbreak affect primarily spruce-fir forest and subalpine grassland within the SUP area. These areas do not provide breeding habitat for the threatened Mexican spotted owl, the threatened bald eagle, the endangered black-footed ferret, or the sensitive peregrine falcon. The SUP area provides occasional foraging habitat for the sensitive northern goshawk. Since this species forages in both forested stands and along the edges of openings, initial development of the ski area and subsequent maintenance activities are unlikely to have had a substantially positive or negative effect on this species. Development of approximately 139 acres of skiing trails has increased the amount of potential habitat for the sensitive Navajo Mountain Mexican vole within the SUP area. Maintenance of existing ski trails may periodically impact some vole habitat and/or individuals.

Some of the past, present, and reasonably foreseeable future actions identified above have cumulative affected habitat for threatened, endangered, or sensitive species. Designation of the Kachina Peaks Wilderness Area provides conservation of potential habitat for the Mexican spotted owl, the northern goshawk, and the Navajo Mountain Mexican vole. Maintenance activities along the Transwestern Lateral Pipeline and the power line between the SUP area and Snowbowl Road may result in the occasional removal of hazard trees from within goshawk PFAs in the area. Proposed construction and use of the Peaks Segment of the Arizona Trail will result in recreational impacts to the Veit Springs goshawk PFA. A portion of the Snowbowl Road is located within the Snowbowl PAC. This roadway supports year-round traffic associated with winter sports, as well as other traffic related to the Scenic Sky Ride and other recreational events staged within the SUP area. Consistent presence and reproductive success suggest that traffic on Snowbowl Road has had little if any effect on Mexican spotted owls nesting in this PAC.

Management Indicator Species

Establishment of the Snowbowl SUP classified a total of 777 acres for recreational use, precluding the management of this area for indicator species. Establishment of the ski area in 1938 has likely had little effect on management indicator species beyond the SUP.

Other the past, present, and reasonably foreseeable future actions have affected management indicator species in the Peaks area. Closure and reclamation of the White Vulcan Mine and withdrawal of the Peaks from mineral extraction will benefit some management indicator species in the future. Designation of the Kachina Peaks Wilderness Area provided 18,705 acres for management as a Wilderness area. As such, forest management activities are precluded and habitat conditions are predominantly the result of natural events, such as fire, succession, insect pest outbreaks. The Fort Valley Restoration Project will restore 9,100 acres of ponderosa pine forest to pre-settlement conditions and will likely improve habitat conditions for species indicative of late seral ponderosa pine forest. Private lands in the Fort Valley and Baderville area, including portions of Lower Hart Prairie, are mostly zoned at one unit per two to 2.5 acres; however, some are zoned at one unit per five or ten acres for lands undergoing development for rural residential uses.[414] Increased human presence and development reduces the amount of habitat for elk and mule deer in the analysis area. Construction and maintenance of the Transwestern Lateral Pipeline resulted in the clearing of approximately four acres of ponderosa pine forest which probably improved foraging habitat for elk and mule deer.

Migratory Birds

Initial development of the Snowbowl ski area affected habitat for migratory birds within the SUP area. Clearing of ski runs and construction of associated facilities affected roughly 160 acres of predominantly spruce-fir forest and to a lesser degree subalpine grassland. Of this total, 21.4 acres were developed as roads, parking lots, and permanent structures which no longer serve as habitat for migratory birds. The remaining 138.6 acres was predominantly spruce-fir forest that was converted to open areas comprising the existing ski runs. This resulted in a corresponding loss of potential habitat for the Swainson's thrush. Potential habitat for pine grosbeaks and golden-crowned kinglets was negatively affected through the removal of overstory vegetation and positively affected by the creation of more edge habitat and more open areas for foraging. Potential habitat for olive-sided flycatchers likely increased through the creation of more openings. Construction of the Hart Prairie Lodge, lifts, and ski trails has likely reduced habitat quality for foraging ferruginous hawks. Removal of spruce-fir trees to control spruce bark beetles will reduce habitat quality for three-toed woodpeckers, which feed preferentially on these insects. Construction of the Agassiz Lift (to the original top terminal location) affected roughly two acres of habitat for the water pipit.

Designation of the Kachina Peaks Wilderness Area has conserved 18,705 acres of high elevation montane conifer forest and grassland. To some extent, this has benefited most or all of the migratory birds discussed above. Withdrawal of the Peaks from mineral extraction also provides conservation of these species or their potential habitats. The Fort

[414] Coconino County Community Development, 2003

Valley Restoration project will likely improve habitat conditions for the olive-sided flycatcher while private land development in Lower Hart Prairie is reducing foraging habitat for the ferruginous hawk.

Game and Non-game Wildlife

Initial development of the Snowbowl has affected game and non-game wildlife primarily through disturbance from recreational and other human activities and from fragmentation or disruption of continuous forest cover within the SUP area. The highest levels of human activity occur during the ski season; the presence of skiers primarily results in the disturbance of diurnally foraging birds and other wildlife outside the breeding season. Use of the SUP as a recreational area has likely increased the local abundance of potential nest scavengers, such as jays, crows, and ravens and other nuisance wildlife, such as bears. Summer recreational use is in large part related to the Scenic Sky Ride. This activity may cause disturbance to foraging or potentially breeding birds and other wildlife in the direct vicinity of the Agassiz Chairlift. Initial development of the ski area converted 138.6 acres of spruce-fir forest to ski trails, creating a mosaic of forested and open areas within the SUP area. This has resulted in direct habitat loss, limitations on movement between forest patches, and potential edge effects such as greater nest predation rates for some wildlife species.

Designation of the Kachina Peaks Wilderness Area, closure and reclamation of the White Vulcan Mine and withdrawal of the Peaks from mineral extraction will conserve habitat for game and non-game wildlife in the area. Removal of bark beetle infected trees opens up target stands of spruce-fir and affects wildlife through disturbance or direct habitat removal. Maintenance activities related to pipelines, power lines, and roads cause temporary disturbance to wildlife. Establishment of the Peaks segment of the Arizona Trail will contribute to recreational impacts on game and non-game wildlife. Areas adjacent to the Trail may become unsuitable or may be avoided by some species. Construction of a loop trail would likely reduce use of the area by wild turkey. Development of private lands in the Fort Valley/Baderville, Hart Prairie/White Horse Hill areas and recreational use of the Peaks Segment of the Arizona Trail may increase the local abundance of scavengers, such as corvids, and may result in higher rates of nest predation in passerine birds. Greater human presence from recreational use of the Arizona Trail and from development of private lands in the Fort Valley/Baderville, Hart Prairie/White Horse Hill areas will further restrict, but not impede, movement of large carnivores through the analysis area. These activities would also result in a cumulative increase in the frequency of encounters between humans and bears in the analysis area.

Alternative 2 – The Proposed Action

Threatened, Endangered, and Sensitive Species

Cumulative effects of the Proposed Action on threatened, endangered, and sensitive species are the same as those described under Alternative 1, with the following exceptions.

Clearing of new ski trails under the Proposed Action would increase the area of potential habitat for the sensitive Navajo Mountain Mexican vole from approximately 138.6 to 233.1 acres. Snowmaking would increase grass and forb density and cover and may result in an increase in vole populations on both the existing and new ski trails. A correspondingly larger area would be subject to maintenance activities, which may temporarily disturb vole habitat and/or affect individuals. This alternative would result in the removal of 54 pine trees from the Mars Hill northern goshawk PFA.

Management Indicator Species

The Proposed Action would not change the boundaries or the total acreage associated with the Snowbowl SUP area. As such, it would not affect the total acreage managed as a recreational area and excluded from management for forest indicator species. Due to their location, number, and size, the removal of approximately 156 trees from along Snowbowl Road and the reclaimed water pipeline alignment would not affect most management indicator species. Associated ground disturbance and removal of approximately 22 smaller aspen trees may temporarily reduce potential foraging habitat for mule deer. Otherwise, cumulative effects are the same as those described under Alternative 1.

Migratory Birds

Cumulative effects of the Proposed Action on migratory birds are the same as those described under Alternative 1, with the following exceptions.

Cumulative effects under this alternative would relate to the removal, disturbance, or modification of a total of approximately 305.6 acres of montane conifer forest and grassland within the SUP. This consists of approximately 160 acres affected as a result of past ski area development and proposed improvements that would remove an additional 76.3 acres of spruce-fir forest, remove 2.7 acres and temporarily disturb 18.2 acres of subalpine grassland, and thin 48.4 acres of spruce-fir forest within the SUP area. Approximately 150 trees have already been removed from the SUP area and an additional 800 are planned to be removed for the control of spruce bark beetles. This alternative would result in a corresponding cumulative increase in the amount of potential habitat lost or modified for the Swainson's thrush, pine grosbeak, golden-crowned kinglet, ferruginous hawk, and three-toed woodpecker. This alternative would contribute an additional one-half-acre loss of potential habitat for the water pipit but would result in a cumulative increase in the amount of potential habitat for the olive-sided flycatcher.

Game and Non-Game Wildlife

Cumulative effects of the Proposed Action on game and non-game wildlife are the same as those described under Alternative 1, with the following exceptions.

This alternative would cumulatively increase the amount of open area dominated by forbs and grasses from roughly 138.6 acres to approximately 233.1 acres and would increase the productivity of the predominantly introduced plant species in these areas. This would further improve habitat conditions for elk, mule deer, other generalist herbivores, and edge species but would reduce habitat for specialist herbivores and forest interior species.

This alternative would result in a cumulative increase in the area subject to disturbance effects. Maintenance activities would be extended from approximately 138.6 to 233.1 acres and most of the existing and new trails would be subject to noise from snowmaking and grooming operations. Establishment and use of the proposed hiking trail would result in potential disturbance of an additional 15 acres during the summer period. This alternative would extend the ski season and would increase the total duration over which potential disturbance of wildlife occurs. This increased human presence would affect primarily diurnally foraging birds and other wildlife outside the breeding season. An extended ski season may cumulatively increase the local abundance of potential nest scavengers, such as jays, crows, and ravens and other nuisance wildlife, such as bears.

Removal of approximately 76.3 acres of spruce-fir forest would result in a cumulative decrease in continuous forest cover and an increase in the total amount of edge between open and forested areas. Creation of additional edge may cumulatively increase nest predation rates by corvids. The Proposed Action would result in greater patchiness and would further reduce cover for large carnivores.

Alternative 3

Threatened, Endangered, and Sensitive Species

Cumulative effects of this alternative on threatened, endangered, and sensitive species are the same as those described under Alternative 1, with the following exceptions.

Clearing of new ski trails under this alternative would increase the area of potential habitat for the sensitive Navajo Mountain Mexican vole from approximately 138.6 to 205 acres. Grass and forb density and cover would be dependent on natural precipitation. No trees would be removed from the Mars Hill northern goshawk PFA.

Management Indicator Species

Cumulative effects on management indicator species are the same as those described under Alternative 1, except that there would be no removal of trees along Snowbowl Road and the reclaimed water pipeline alignment under this alternative, and therefore no temporary impacts to mule deer foraging habitat.

Migratory Birds

Cumulative effects of this alternative on migratory birds are the same as those described under alternatives 1 and 2, with the following exceptions.

The cumulative effect of past ski area development and proposed additional development under this alternative would be the removal, disturbance, or modification of approximately 274.9 acres of montane conifer forest and grassland within the SUP area. This consists of 160 acres affected as a result of past ski area development and proposed improvements that would remove an additional 66.4 acres of spruce-fir forest, remove 0.1 acre of subalpine grassland, and thin 48.4 acres of spruce-fir forest within the SUP area. This alternative would result in a corresponding cumulative increase in the amount of potential habitat lost or modified for the Swainson's thrush, pine grosbeak, golden-crowned kinglet, ferruginous hawk, and three-toed woodpecker. Like the Proposed Action, Alternative 3 would contribute an additional one half-acre loss of potential habitat for the water pipit but would result in a cumulative increase in the amount of potential habitat for the olive-sided flycatcher.

Game and non-Game Wildlife

Cumulative effects of this alternative on game and non-game wildlife are the same as those described under Alternative 1, with the following exceptions.

This alternative would cumulatively increase the amount of open area dominated by forbs and grasses from approximately 138.6 acres to 205 acres and would expand the amount of foraging habitat for elk, mule deer, other generalist herbivores, and edge species. It would result in a corresponding reduction in the amount of habitat for specialist herbivores and forest interior species.

This alternative would result in a cumulative increase in the area subject to disturbance effects. Maintenance activities would be extended from approximately 138.6 to 205 acres and most of the existing and new ski run would be subject to noise from nighttime snow grooming operations.

Removal of approximately 66.4 acres of spruce-fir forest would result in a cumulative decrease in continuous forest cover and an increase in the total amount of edge between open and forested areas. Creation of additional edge may cumulatively increase nest predation rates by corvids, would result in greater patchiness, and would further reduce cover for large carnivores.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

No irreversible or irretrievable effects or commitment of wildlife resources would occur as a result of implementation of the Proposed Action. Proposed improvements in the analysis area do not preclude potential future habitat restoration activities.

3L. GEOTECHNICAL

In conjunction with this EIS, a geotechnical report was prepared by Myers Design Engineering, Inc. to analyze the feasibility and potential hazards of constructing a 10 million gallon, on-mountain snowmaking water impoundment. The following analysis is excerpted from the Geotechnical Report for the Arizona Snowbowl Facilities Improvement Proposed Snowmaking Pond Site,[415] which is contained in the project file at the Peaks Ranger District.

Appendix A provides a conceptual design of the snowmaking water impoundment, which was necessary in order to complete a proper stability analysis and dam breach model. The reader is referred to Appendix A for specifics of the impoundment. A summary of the impound design follows.

The snowmaking water impoundment is proposed to be located just below (and to the south of) the ridgeline along the southern edge of the SUP area – near the top terminal of the existing Sunset Chairlift. The proposed impoundment is to be a geosynthetic lined pond with an earthen embankment. The conceptual design assumes a 15-foot wide embankment crest and a 15-foot wide access road around the perimeter of the pond for maintenance access. The impoundment would be constructed with 2:1 (horizontal to vertical) side slopes. Although the Proposed Action calls for a 10 million gallon capacity, maximum possible storage (to the embankment crest) would be approximately 12.6 million gallons (38.8 acre feet). This makes the structure a non-jurisdictional dam in the State of Arizona (less than 25-foot crest to toe embankment height and less then 50 acre feet of storage).

SCOPE OF THE ANALYSIS

Detailed field mapping of geologic hazards over the entire ski area was determined to be unnecessary in relation to the scope of this analysis. This hazard assessment is limited to the review of available published information, site-specific topographic maps, available aerial photography, and a field inspection of the proposed snowmaking water impoundment site.

EXISTING CONDITIONS

TOPOGRAPHY AND SOILS

The Snowbowl (and the proposed snowmaking water impoundment site, specifically) is located in the San Franciscan Volcanic Field of northern Arizona, north of Flagstaff, near Latitude 35° 19’ 49” North, Longitude 111° 42’ 30” West. The proposed snowmaking pond is proposed near the upper terminal of the existing Sunset Chairlift, at an elevation of approximately 9,990 feet. This area drains south and east into the Rio de Flag near US Highway 180. The area is in the south/central portion of the Colorado Plateau physiographic province.

[415] Myers, 2003

Site topography is steep with slopes below the snowmaking pond site ranging from 15 to 50 percent. Bedrock at the site consists of extrusive igneous rock, specifically blocky lavas of medium gray to pinkish gray andesite containing phenocrists of plagioclase feldspar, horneblende, hypersthene, and augite of Quaternary age. Materials of similar mineralogic composition can also exist in the form of ashflow tuff, tuff breccias, and flow breccias. The formation present at the snowmaking impoundment site is designated "Younger andesite of Agassi Peak" (Qaay). The formation common to higher elevations is designated "Older andesite of San Francisco Mountain" (Qao). Outcrops are relatively uncommon except along the ridge tops at higher elevations. Other commonly observed materials include colluvium, alluvium, and avalanche/debris flow deposits.

A soil survey prepared by the CNF is available for the area. The predominant soil complex in the vicinity is described as having a severe erosion potential, slight cutbank stability potential, and low shrink/swell potential. Other soil units encountered along the drainage path between the proposed snowmaking water impoundment site to and along Rio De Flag are grouped according to "mountainous" and "valley" sections. Erosion hazard ranges from moderate to severe in the mountainous section, and from slight to severe in the valley floor section. Cutbank stability hazard varies from slight to moderate in the mountainous section, and slight to non-existent in the valley floor section. The severe erosion hazard, particularly in the uppermost portions of the identified flow path, indicates that flood flows are likely to carrying a high sediment load and have the potential to generate debris flows.

GEOLOGIC HAZARDS

Large landslides were not observed despite the steep terrain. However, combined avalanche and debris flow chutes are relatively common in the vicinity of the Snowbowl at higher elevations. The drainage path for any significant hydrologic event at the snowmaking water impoundment site (including a dam breach flood) is southwest off the face of Agassi Peak, then southeast along the Rio De Flag toward the City of Flagstaff. The estimated flood discharge for the Rio De Flag at the city limits of Flagstaff is 340 cubic feet per second (cfs) for a return frequency of 25 years.

Other potential geologic hazards that were considered include: avalanche; rockfall; earthquake; subsidence; and expansive soils. There is a significant avalanche risk on all slopes between 26° and 45° (approximately 50 to 100 percent) which is further aggravated in areas of significant wind loading. However, the avalanche hazard is routinely monitored and mitigated during Snowbowl's safety operations. No significant rockfall hazard was observed anywhere within the immediate vicinity of the proposed snowmaking water impoundment area. Slopes are gentle to moderate with no exposed rock.

The total absence of carbonate rocks (limestone and dolomite) precludes the existence of any karst topography or associated sinkhole development and therefore also precludes the associated subsidence risk. Similarly, although extrusive volcanic rocks are present in the area, there is no evidence of shallow lava tubes that could create a subsidence hazard. No significant mining activity has ever existed at the site and therefore, there are no shafts or slopes that could present a subsidence risk. No groundwater pumping is carried out, and therefore subsidence associated with groundwater pumping is not an issue at the Snowbowl.

Mechanical weathering dominates over chemical weathering at this relatively high altitude. The residual and colluvial soil products that result from breaking down the andesitic rocks tend to be fine-to-medium grained sands with little or no clay (i.e., non-plastic). Therefore, the soils are non-expansive (little shrink-swell activity).

SEISMICITY

This section of the analysis describes the potential impact of earthquakes at the Snowbowl by separately addressing two distinctly different aspects of seismicity:

- Seismic hazard
- Seismic risk

Seismic hazard addresses the nature of and likelihood of experiencing a seismic event at sometime in the future. However, the characterization of *seismic risk* requires more than just the establishment of a hazard and necessarily requires the consideration of the potential consequences of experiencing a seismic event.

Seismic Hazard

Seismic events or earthquakes have long been known to be associated strongly with tectonic movements of large masses of the earth's crust or plates. Earthquakes can and do occur virtually anywhere in the earth's crust, but tend to concentrate, both in space and time, near the boundaries of the major plates. They can be associated with magmatic movement and volcanism, with areas of crustal thinning or spreading centers (rift zones), or even from elastic crustal rebound and isostatic uplift following the removal of a great thickness of glacial ice. However, the largest earthquakes and the greatest frequency of earthquakes seem to be associated subduction zones where edge of one plate is sinking beneath the edge of an adjacent plate that is overriding it. Arizona (with the exception of the extreme southwest corner near Yuma) is not impacted by plate boundary, subduction zone tectonics. Most earthquakes are directly associated with the breaking or rupture of the crust along a fault line. The magnitude of the earthquake is a function of a number of factors including the type of rock present, the dip angle of the subduction zone, the depth of the rupture, the creep rate and magnitude of the stress drop during a rupture, the areal extent of the rupture, and so on.

The Snowbowl SUP lies in a Zone 2B seismic area in the Colorado Plateau – a region characterized by crustal uplift. A database was created of earthquake magnitude and the epicenter location of historic seismic events within a 100 km radius of the site extracted from the USGS seismic event catalog. In many areas of moderate to low seismicity, earthquakes can be considered to occur as independent, random events in space and time and can be modeled using probability models that assume a dispersed source area (such as the area of the circle defined by the arbitrary 100 km radius surrounding the site). However, in areas of high seismicity, earthquakes do not occur randomly, but are often clustered along active fault lines. For purposes of this analysis, it was assumed that the seismic source area contains the full population of historic events within a 100 km radius of the site.

The Flagstaff community has experienced several damaging earthquakes from seismogenic sources within northern Arizona. The region between Flagstaff and the Arizona-Utah border has produced seven M_S[416] 5.0 historic earthquakes. The three largest occurred within a six-year period (1906-1912).

- January 25, 1906: M_S 6.2
- September 24, 1910: M_S 6.0
- August 18, 1912: M_S 6.2

Earthquakes are felt in Flagstaff about once per year. Part of the reason for this is that the Colorado Plateau transmits earthquake energy relatively efficiently. However, the primary reason is Flagstaff's location within the Northern Arizona Seismic Belt (NASB).[417] The most recent strongly felt earthquakes[418] stemmed from the 1993 Cataract Creek earthquake sequence of April and May. This sequence included both a m_b 4.9[419] foreshock and m_b 5.4 mainshock that were both widely felt in Flagstaff. More recently, earthquakes ranging up to M_L[420] 3.7 struck the Red Mountain and Lake Mary regions. These later events were only slightly felt in Flagstaff. In addition, earthquakes centered at the South Rim of the Grand Canyon ranging up to M_L 4.0 have occasionally been felt in Flagstaff.

Earthquakes no larger than magnitude seven would be expected in the seismic source area, and no larger than 6.5 in the vicinity of the site.

Design Earthquake

Analysis of the historic earthquake record as described above, and detailed in the Geotechnical Report prepared for this analysis, shows the following characteristics for the design earthquake (the event which should be used for the design of important facilities) for a facility design life of 100 years:

- Magnitude = 6.2
- Maximum On-Site Bedrock Acceleration (6.2 at 22 km) = 0.15g
- Annual Exceedance probability = 1.0 percent

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[416] Surface Wave Magnitude. A relationship can be established between estimates of any of the various wave types that can be observed on a seismogram (P waves, S waves, and Rayleigh waves [also called surface waves]). M_s is estimated using the surface waves and is particularly useful for shallow focus earthquakes.

[417] The NASB is composed of a northwesterly trending belt of seismicity beginning southeast of Flagstaff, trending through the Grand Canyon, and apparently joining with a northward trending belt of seismicity at the Arizona-Utah border.

[418] MMI V-VI[418] in Flagstaff.

[419] Body Wave Magnitude. This magnitude is estimated using the P wave amplitude.

[420] Local Magnitude (also known as the Richter Magnitude) is a procedure developed by Charles Richter in 1935 in California, specifically for the Wood-Anderson Seismograph instrument and was intended for use in characterizing California earthquakes (although it has seen much wider usage). It uses the difference in arrival time between the P wave (compression wave) and the S wave (shear wave) along with the maximum height (or amplitude) of the shear wave on the seismogram to determine the magnitude.

- Probability of Occurrence During Design Life of 100 years = 63.21 percent
- Idealized Length of Fault Slip (Rupture Length) = 6.6 miles
- Probable Maximum Offset = .39 meters (1.3 feet)
- Expected Duration of Strong Ground Motion = 15 seconds
- Expected Duration of Acceleration greater than 5%g = 14 seconds
- Expected Duration of Acceleration greater than 10%g = 10 seconds

The above event could occur anywhere within the seismic source area defined by the 100 km radius around the site. However, the effects of earthquake shaking (acceleration, particle velocity, etc.) attenuate quickly with distance. Therefore, the worst-case conditions are likely to come from a nearby source, even if the magnitude of that event is less than the magnitude of the design event from within the entire seismic source area.

Maximum Credible Earthquake

The concept of Maximum Credible Earthquake (MCE) uses the characteristics of a specific fault system to set a practical limit on the magnitude of the event it can generate. It is based primarily on the length and character of the mapped fault rupture. The most likely source of large seismic events in the vicinity of the site is the neotectonic fault system located to the southeast of Flagstaff. This fault system has been assigned a MCE magnitude of 7.3.

Worst Case Event Characteristics are as follows:

- Maximum Credible Earthquake Magnitude = 7.3
- Maximum On-Site Bedrock Acceleration (7.3 at 22 km, 25 km rupture on Lake Mary fault system, Baush and Brumbaugh, 1997) = 0.27g
- Annual Exceedance probability = 0.17 percent
- Probability of Occurrence During Design Life of 100 years = 15.32 percent
- Idealized Length of Fault Slip (Rupture Length) = 40 miles
- Probable Maximum Offset = 1.3 meters (4.3 feet)
- Expected Duration of Strong Ground Motion = 28 seconds
- Expected Duration of Acceleration greater than 5%g = 29 seconds
- Expected Duration of Acceleration greater than 10%g = 14 seconds

Seismic Risk

Seismic risk must necessarily consider the potential consequences of the seismic hazard on facilities, equipment, and personnel associated with the project. The nature of the potential impacts varies depending on whether facilities are considered temporary, have a fixed life, or are considered permanent. Facilities can be impacted in a number of ways including surface ground rupture, strong shaking, liquefaction, and seismically induced instability.

All fixed structures at the site would be impacted by strong ground motion independent of their position at the site. For most facilities, the magnitude threshold at which some level of damage might be expected is about 5.0 with the severity of damage increasing with increasing magnitude. Probability of impact is simply the probability of the occurrence of the event.

Liquefaction, or the sudden loss of strength in the foundation soils supporting structures, typically begins at a magnitude threshold on the order of 6.0. However, the phenomenon requires not only strong ground motion, but also the presence of loose, saturated, non-cohesive soil. Although these conditions can exist locally where deeply weathered pockets in the bedrock have been filled with loose granular soil, the conditions are rare and isolated. The snowmaking water impoundment site does rest above a pocket of residual and colluvial soil roughly eight to 10 feet thick above the volcanic bedrock. The colluvial soil in the upper one to 2.5+/- feet is relatively loose, however the density and cobble/boulder content increases with depth as the material transitions into a moderate to high-density residual soil with cobbles and boulders that becomes weathered volcanic bedrock at some depth greater than eight to 10 feet. The soils are normally dry and it is unlikely that they would fully saturate even during heavy snowmelt conditions. Based on the design 100 year return frequency earthquake (magnitude 6.2, barely above the threshold magnitude of 6.0), and an inspection of test pit excavations, it is believed that liquefaction risk at the snowmaking pond site is low.

Potential impacts from ground rupture during seismic events affect primarily permanent, fixed linear facilities such as roads, lifts, pipelines, and so on. Surface ground rupture has been documented during events as small as magnitude 3.6,[421] however, as a general rule, surface fault rupture requires events larger than magnitude 5.5. No known active faults exist on the site, and therefore the risk of impact from surface fault displacement is minimal.

Another potential consequence of a major seismic event is the occurrence of seismically induced instability. The most common seismically induced events include rockfalls, disrupted soil slides, and rockslides.

ENVIRONMENTAL CONSEQUENCES

DIRECT AND INDIRECT EFFECTS

Based on an analysis of the existing conditions within the Snowbowl SUP area, no geotechnical concerns were identified for any of the proposed project elements with the exception of the construction and on-going operation of the proposed snowmaking water storage impoundment. Because the snowmaking water impoundment is not a component of either Alternatives 1 or 3, this discussion of environmental consequences is limited to Alternative 2.

[421] Imperial, California, 1966.

Issue:

Geotechnical feasibility and hazards associated with construction of the proposed snowmaking water impoundment must be analyzed.

Indicator:

Dam Breach and Downstream Inundation Analysis

The character and potential impact of a dam breach flood was evaluated for the proposed snowmaking water impoundment using the unsteady flow modeling capabilities of the HEC-RAS program developed by the U.S. Army Corps of Engineers. HEC-RAS calculates the peak discharge through the breached dam and routes the flood wave downstream. The program uses an implicit finite difference procedure to solve the complete one-dimensional Saint-Venant equations of unsteady flow. Figure 3L-1 depicts the potential flow path.

Insert Figure 3L-1 – Dam Breach Flood Map

In the event of a snowmaking water impoundment failure, the resulting flood would flow to the southwest, away from the developed terrain within the SUP area, and further south down unnamed drainages approximately five miles to the valley floor and the Rio De Flag. Most of the flow path is steep and often narrow and supercritical flow would dominate. The upper part of the channel is steep, producing high stream power and Froude numbers often above 2.0. Such conditions can result in severe erosion and scour. However, at the base of the mountain (approximately five miles below the impoundment location), floodwaters would spread out across a wide, flat floodplain area where most of the sediment would be deposited.

The HEC-RAS program requires the input of numerous parameters. However, some of the most important parameters are those that describe the ultimate shape of the breach in the embankment, and the time required for the breach to form. <u>Due to the nature of the snowmaking water impoundment design (a geosynthetic lined pond excavated well below the embankment height into natural ground), only a partial breach would be expected with the portion of the reservoir well below natural ground not being released.</u> Froelich equations of were used to obtain initial estimates of the average breach width and time to failure.[422] Additional equations that provide estimates of the peak discharge during breach were used to provide an independent check on the reasonableness of the breach parameters.[423] Given the sandy, cohesionless, and erodible nature of the embankment soils, it is expected that the elapsed time from the beginning of failure to the maximum breach development would be minutes (not hours). After some attempts at optimization, the following breach parameters were selected:

- Average breach width = 44 feet
- Max width at bottom of breach = 31 feet
- Breach side slopes = 0.77:1
- Maximum breach height = 17 feet
- Time required for breach development: 10.2 minutes

Two different failure mechanisms were considered; a sunny day piping failure (internal erosion), and an overtopping failure. The overtopping failure condition would be the result of operating error (the structure overfilled and overtopped) and not be the result of a hydrologic event (i.e., no inflow flood hydrograph is being routed along with the dam breach flood).

The dam breach flood would be discharged on the south side of the ridge that bounds the Snowbowl and would not be released onto an existing or proposed trail. The maximum discharge through the breach varies among the scenarios ranging from 1,380 cubic feet per second (cfs) for the piping failure mode to 1,165 cfs for the overtopping failure mode. In the mountainous section of the modeled flow path, flow depth can be as great as 1.7 feet (although the typical depth is roughly one foot). Velocities in the steep upper reaches can be as high as 23.5 feet per second (fps). However, most of the time, the flow velocity would range between five and 14 fps.

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[422] Froelich 1987, 1995

[423] Hagen, 1982; Fread, 1981

There are three structures shown along the flood path between the snowmaking water impoundment site and Fort Valley in the vicinity of Big Leroux Spring, the first at a distance of 4.1 miles below the site and the other two at a distance of 4.3 miles. Two of the structures are outside the mapped flood limits and one is within it. At the site of the structure within the flood limits, the expected peak discharge is 830 cfs, the expected velocity is 5.1 ft/s and the expected mean depth 1.2 feet.

By the time the modeled flood wave reaches the valley floor near U.S. Highway 180 approximately 5.4 miles below the snowmaking impoundment site, there is no difference in the magnitude of the flood discharge under either scenario (between 414 cfs and 419 cfs). The expected peak discharge is 419 cfs, the expected velocity is 3.5 ft/s and the expected mean depth 0.6 feet. The model assumes an existing base flow of 180 cfs, therefore the dam breach flood produces a net increase of 239 cfs to this point. Once the flow reaches the alluvial valley floor, the depth falls to on the order of 0.6 feet just before reaching U.S. Highway 180.

A large, flat storage area exists immediately upstream of U.S. Highway 180 that would allow most of the coarse sediment load to drop out. Therefore, it is expected that existing hydraulic structures would not be plugged and would be functioning. Using existing estimates of peak flood discharges on the Rio De Flag from gaging station records, the 100-year return frequency flood in the area is estimated to be approximately 300 cfs. If the breach flood occurred while the channel is dry (the most likely scenario), then it would have approximately the same impact as a 50-year return frequency flood at the site, and the risk of overtopping the Highway would be low. If there were significant flow in the channel at the time of a breach, then it is possible that the Highway could be overtopped for a brief period of time (the period of time during which flows could exceed 300 cfs would be approximately 15 minutes). The depth of any overtopping flow on the Highway would likely be less than two inches with a velocity of less than 2.0 ft/s.

Downstream of Fort Valley the breach flood is substantially attenuated and would have impacts similar to 25-year return frequency flood or less (less than a 10-year return frequency flood in many cases further downstream). Once the flow enters the channel of the Rio De Flag, the modeled flow velocity declines from roughly 3.5 fps near the confluence to less than 0.3 fps near the first significant residential development (Fort Valley subdivision) at a downstream distance of 5.8 miles. The time required for the leading edge of the flood wave to reach U.S. Highway 180 after the start of a failure is approximately 28 minutes with the peak of the flood arriving approximately 10 minutes later (for a time to peak of 38 minutes).

Therefore, the model indicates that the flood wave attenuates substantially on its way down the mountain and dissipates almost entirely in the broad floodplain of Fort Valley. For purposes of computational stability, the model assumes an existing, minimum flow in the channel of 180 cfs (approximately the equivalent of a 25-year return frequency flood on the Rio de Flag above Flagstaff). The cumulative discharge leaving Fort Valley would be less than 210 cfs (i.e., a net contribution from the dam breach flood of 30 cfs or less). Downstream from Fort Valley, it is anticipated that existing hydraulic structures (bridges, culverts, etc.) on the Rio De Flag would accommodate the passing breach flood without impact through the Flagstaff area.

Indicator:

Hazard Classification

There is no simple, quantifiable method for the assignment of a hazard classification to a reservoir. Classification is a matter of judgment. Most systems consider two main factors:

- The potential for loss of human life
- The potential for property damage

The approach to hazard classification also varies with the administering entity (usually a state or federal agency). For example, the State of Arizona has the following guidance with respect to hazard classification:

Hazard Potential Classification – State of Arizona

1. The Department shall base hazard potential classification on an evaluation of the probable present and future incremental adverse consequences that would result from the release of water or stored contents due to failure or improper operation of the dam or appurtenances, regardless of the condition of the dam. The evaluation shall include land use zoning and development projected for the affected area over the 10 year period following classification of the dam. The Department considers all of the following factors in hazard potential classification: probable loss of human life, economic and lifeline losses, and intangible losses identified and evaluated by a public resource management or protection agency.

    a. The Department bases the probable incremental loss of human life determination primarily on the number of permanent structures for human habitation that would be impacted in the event of failure or improper operation of a dam. The Department considers loss of human life unlikely if:

        i. Persons are only temporarily in the potential inundation area
        ii. There are no residences or overnight campsites
        iii. The owner has control of access to the potential inundation area and provides an emergency action plan with a process for warning in the event of a dam failure or improper operation of a dam.

    b. The Department bases the probable economic, lifeline, and intangible loss determinations on the property losses, interruptions of services, and intangible losses that would be likely to result from failure or improper operation of a dam.

2. The four hazard potential classification levels are very low, low, significant, and high, listed in order of increasing probable adverse incremental consequences. The Director shall classify intangible losses by considering the common or unique nature of features or habitats and temporary or permanent nature of changes.

a. Very Low Hazard Potential. Failure or improper operation of a dam would be unlikely to result in loss of human life and would produce no lifeline losses and very low economic and intangible losses. Losses would be limited to the 100 year floodplain or property owned or controlled by the dam owner under long-term lease. The Department considers loss of life unlikely because there are no residences or overnight camp sites.

b. Low Hazard Potential. Failure or improper operation of a dam would be unlikely to result in loss of human life, but would produce low economic and intangible losses, and result in no disruption of life-line services that require more than cosmetic repair. Property losses would be limited to rural or agricultural property, including equipment, and isolated buildings.

c. Significant Hazard Potential. Failure or improper operation of a dam would be unlikely to result in loss of human life but may cause significant or high economic loss, intangible damage requiring major mitigation, and disruption or impact on lifeline facilities. Property losses would occur in a predominantly rural or agricultural area with a transient population but significant infrastructure.

d. High Hazard Potential. Failure or improper operation of a dam would be likely to cause loss of human life because of residential, commercial, or industrial development. Intangible losses may be major and potentially impossible to mitigate, critical lifeline services may be significantly disrupted, and property losses may be extensive."

Forest Service Manual 7500, Chapter 7510

Classify dams according to hazard potential based on the loss of human life or property damage that could occur if the structure failed.

1. Low Hazard. Dams built in undeveloped areas where failure would result in minor environmental or economic loss, damage would be limited to undeveloped or agricultural lands, and significant improvements are not planned in the foreseeable future. Loss of human life would be unlikely.

2. Moderate Hazard. Dams built in areas where failure would result in serious environmental damage or appreciable economic loss with damage to improvement, such as commercial and industrial structures, public utilities and transportation systems. No urban development and no more than a small number of habitable structures are involved. Loss of human life would be unlikely.

3. High Hazard. Dams built in areas where failure would likely result in loss of human life or excessive economic loss. Generally this would involve urban or community development with more than a small number of habitable structures."

Hazard classifications are based solely on downstream conditions and not on the design of the structure, operating procedures, or the condition of the dam. For structures assigned a low or moderate/significant hazard classification, periodic review of the hazard classification is appropriate to account for potentially changing downstream conditions. A review frequency on the order of five years is typical.

Hazard classifications affect design criteria (primarily spillway design), and the need for and nature of an Emergency Action Plan. An Emergency Action Plan defines appropriate response scenarios for all potential modes of failure and includes specific notification plans (updated at least every two years with current phone numbers), and evacuation plans. All responsible operating staff must be familiar with the Emergency Action Plan.

Given the long site distance on this section of U.S. Highway 180 and the low depths and velocities, an overtopping event of the Highway would not be life threatening. The subdivision within Fort Valley post-dates the USGS topography, and the structure base elevations are not known. However, the breach flood at the subdivision location would be less than the 100-year flood and would not be expected to impact any existing structures. However, a considerable volume of shallow water would be stored in open areas within Fort Valley during the passage of a breach flood. It is anticipated that existing hydraulic structures (bridges, culverts, etc.) on the Rio De Flag in the Flagstaff area would accommodate the passing breach flood without impact.

Based on the conditions described above in the Dam Breach and Downstream Inundation Analysis, the structure would classify as a low hazard dam using the State of Arizona criteria, and a moderate hazard dam using the Forest Service criteria. Therefore, it is recommended that the final structure be designed using design criteria associated with a moderate hazard dam.

Indicator:

Failure Risk

It is extremely important to understand the distinction between *hazard* and *risk*. A *hazard* is a condition, either natural or human-made, that poses a *potential* danger to life and/or property. Hazards exist everywhere, all around us. The existence of a hazard says absolutely nothing about the likelihood of being impacted by the hazard. *Risk* is the probability of occurrence of the event that would cause the impact. Stated another way, the hazard associated with a potential dam breach flood is exactly the same whether the dam embankment is a state-of-the-art structure in good condition or a poorly designed, sloppily constructed structure in poor condition. However, the risk or the probability that the embankment might fail, leading to the occurrence of a dam breach flood, would be dramatically different for those two extremes.

The principle determinant of the risk of experiencing a dam breach flood is the structural stability of the dam embankment. Potential failure modes were evaluated to assess failure risk along with the identification of mitigation measures that could reduce failure risk.

Potential dam embankment failure modes considered include the following:

- Overtopping of the embankment crest due to an extreme hydrologic event
- Overtopping of the embankment crest due to operator error
- Piping development in the downstream toe of the embankment or in the foundation
- Static failure of the embankment
- Embankment failure due to excessive displacement during an earthquake
- Liquefaction of the embankment foundation
- Excessive settlement

Overtopping of the Embankment Crest Due to an Extreme Hydrologic Event or to Operator Error

For a moderate hazard rating, the required uncontrolled spillway design criteria is the Probable Maximum Flood (PMF). Estimation of the Probable Maximum Precipitation (PMP) and the associated PMF is beyond the scope of this study. However, based on the very limited size of the contributing basin above the proposed snowmaking pond, the design PMF is likely to be very small. The level of anticipated discharge should be easily carried through a modest sized emergency spillway placed in one of the dam abutments. The dam abutments contain an abundance of boulders and weathered volcanic rock at or very near the surface. Therefore the erosion potential in the floor of the spillway channel would be minimal. The uncontrolled emergency spillway should be checked routinely and frequently as part of normal operations for potential blockage by snow, ice, or debris and cleared if significant blockage is found.

Operator error could result in overfilling the reservoir if pumps were inadvertently left running unattended. However, using an automatic cutoff switch that would shut down pumps when the water surface in the pond reached its maximum storage level could mitigate this risk (this feature has been specified as required mitigation as detailed in Chapter 2). A pressure sensing transducer on the bottom of the pond should be used in lieu of a float device at the surface of the pond to prevent interference by ice. Even if automated systems were to experience a total mechanical failure, the uncontrolled emergency spillway would still prevent overtopping.

Due to the very low probability of occurrence of the sequence of events that might lead to an overtopping failure and the degree of redundancy possible in mitigation design, there is a very low risk of failure by overtopping.

Piping Development in the Downstream Toe of the Embankment or In the Foundation

Piping involves the transport of solid particles from within an embankment or foundation soil in response to high seepage pressures or seepage velocities. The risk is greatest where certain fine-grained soil types are present and in high head dams (high embankments impounding water to great depth) that can produce high exit gradients (rapidly changing upward pressure gradients in the toe area of the dam). Fine sands and silts that are poorly graded (nearly all the same grain size) are very susceptible to piping. A particularly dangerous soil group is called “dispersive clay.” These very fine-grained soils (less than 2.0 microns) disaggregate in the presence of water and become extremely mobile. None of these high-risk soils are present at the proposed snowmaking water impoundment site. The soils observed on site consist of fine to medium grained, *well*-graded sands with gravel, cobbles, and boulders. "Well graded" refers to a wide variety of different particle sizes that impart good filtering characteristics (large particles hold back the medium sized particles which hold back the small particles and so on) creating a soil with good drainage characteristics and very limited particle mobility. These soils have a low piping potential.

The design maximum embankment height is on the order of 24 feet making the structure a small, low head structure. The impoundment area will be lined with a geo-synthetic liner to create a "bathtub" configuration that, during normal operations, would prevent any release of water to the soil and rock below the reservoir. However, any liners may leak at some point in their life through defects in the liner or more often in the seams that that join sheets of liner. The most common defect is a small pinhole leak producing orifice flow through the liner and into the porous soil beneath. Such leaks, even if they were numerous, would not result in saturation of the foundation and embankment, but would perch and flow harmlessly beneath the structure and out on the bedrock/soil interface. A large leak (a major slice or tear in the liner or a long rip in a seam) could release enough water to saturate the foundation and embankment. Due to the shallow depth to rock, a portion of the back of the reservoir is likely to expose rock or even excavate a short distance into weathered rock. If this process were to expose any open, high continuity (long) joints, then it would be possible for water to directly enter these joints and be delivered with little head loss to the area immediately beneath the toe of the dam producing strong upward flow and high exit gradients leading to a piping risk even in the well graded sands.

This risk can be mitigated in a number of ways. A composite liner system consisting of HDPE liner above a minimum six inch thick bedding of compacted clay would restrict the flow volume sufficiently to prevent saturation of the foundation and embankment soils and create enough head loss to reduce high exit gradients in the toe area of the dam. However, there is no local source of clay soil and the importation of clay liner/bedding material would be very expensive. Another approach would be to grout any open fractures exposed during excavation prior to covering with the local sand bedding and the HDPE liner. The process of filling open fractures from the surface is sometimes referred to as "dental" grouting or "slush" grouting. The plugging of these fractures would either prevent the entry of water into the fractures or at least create enough head loss to reduce exit pressures at the embankment site. A third option would be injection grouting beneath the embankment foundation. Again, the plugging of fractures in the foundation below the embankment would create enough head loss to reduce exit pressures beneath the downstream toe of the embankment.

In summary piping does represent a risk to the stability of the structure, but the piping risk can be mitigated to a low risk by taking appropriate measures during final design and construction.

Static Failure of the Embankment

Slope stability failure in the embankment can cause a loss of crest height and an associated risk of overtopping. The risk of instability is increased in the presence of saturated soil conditions and high pore pressure. Under normal operating conditions the embankment and foundation would be expected to be dry. Even in the presence of small to moderate leakage through the liner, the embankment would be expected to remain dry. Slope stability models were developed and analyzed for the downstream embankment of the snowmaking water impoundment. Rapid drawdown conditions were not analyzed for the upstream embankment slopes because the embankment soils are expected to be relatively free draining and incapable of preserving excess pore pressure following a reduction in impoundment water levels, and under normal operating conditions, there is no connection between impoundment water levels and pore water pressures in the embankment soils. Using an embankment slope of 2:1, the factor of safety (FOS) under the normal dry condition is 2.75, and under a moderate leakage condition 2.71 indicating a very low risk of instability.[424] Under worst-case conditions of major leakage through the liner, the embankment soils would saturate and establish a steady state seepage profile. The FOS under this condition is 2.13 indicating a low risk of instability.

For the proposed embankment slope of 2:1, the risk of static instability is low.

Embankment Failure Due to Excessive Displacement During an Earthquake

Strong ground motion during an earthquake can cause displacements in the embankment that in turn can cause a loss of crest height and an associated risk of overtopping. The potential for unacceptable displacements during an earthquake is checked in a hierarchy of analyses beginning with a pseudostatic limit equilibrium analysis. If the pseudostatic analysis indicates a factor of safety equaling or exceeding 1.15,[425] then there is no need for any additional analysis. For the condition of no leakage the FOS is 2.32, and for small to moderate leakage through the liner 2.28, indicating a low risk of excessive displacement and no need for further analysis. The combined conditions of major leakage with the development of a steady state seepage profile, and the occurrence of a major earthquake would produce a FOS of 1.79, again exceeding normal design criteria. In addition, the probability of a large leak going undetected and unmitigated coinciding with the timing of a large earthquake is extremely low (i.e., it is not a reasonable worst case design condition for this structure).

The risk of excessive displacement during an earthquake is low.

Liquefaction of the Embankment Foundation

Liquefaction is a phenomenon that causes loss of shear strength during the strong ground motion accompanying an earthquake. Liquefaction requires two conditions:

1. Loose cohesionless soils
2. Saturated conditions

Test pits revealed loose, cohesionless soils in the upper 2.0+/- feet of the soil profile, however these soils would not be saturated for the condition of no leakage or even small

[424] For static failures, most structures are designed to a minimum FOS of 1.5. An FOS exceeding 1.5, therefore, has a low likelihood of failure.

[425] For seismic-induced failures, most structures are designed to a minimum FOS of 1.15. An FOS exceeding 1.15, therefore, has a low likelihood of failure during a seismic event.

to moderate leakage through the liner and therefore not subject to liquefaction. The combined conditions of major leakage with the development of a steady state seepage profile, and the occurrence of a major earthquake would have an extremely low probability for the same reasons described in the earlier section on excessive displacement. Test pits indicate that the cohesionless soils densify with depth transitioning into dense residual soils and weathered rock at a depth of less than 10 feet. However, the lower portion of the soil profile could be saturated with only a small to moderate level of leakage through the liner. Based on observations in the test pits, these deeper soils are too dense to be liquefiable. However, it would be prudent to check the relative density of the entire soil profile and quantify the liquefaction potential of the deeper soils through a site-specific drilling program at the time of final design. If a liquefaction risk is identified at the time of final design, it can be easily mitigated. Loose soil can simply be removed and replaced with compacted, densified soil, or deep layers can be stabilized with grout.

In summary, the liquefaction risk is believed to be low, but needs to be verified by site-specific investigation at the time of final design.

Excessive Settlement

Excessive settlement can lead to a loss of crest height and an associated risk of overtopping. Large settlements are typically associated with low-density clay soils. The soils in the foundation area are low cohesion silty sand and gravel becoming progressively denser with depth and terminating against boulders and weathered rock at depths of 10 feet or less. Settlement movements in such soils are small, elastic in nature, and immediate. Therefore, little or no settlement movement would be expected after completion of construction.

The risk of excessive settlement is very low.

CUMULATIVE EFFECTS

Scope of Analysis

Temporal Bounds

The temporal bounds of the cumulative effects analysis for geotechnical issues extends from the point at which the water impoundment would be constructed until it is no longer necessary.

Spatial Bounds

The physical extent of this cumulative effects analysis is confined to the flood inundation path, as identified in Figure 3L-1.

Past, Present, and Reasonably Foreseeable Future Actions

No past, present or reasonably foreseeable future activities have been identified which could cumulatively affect geotechnical resources. Appendix C includes the full list of past, present and reasonably foreseeable future actions analyzed in this document, as well as background information on each of them.

Alternatives 1, 2 and 3

Because no past, present or reasonably foreseeable future activities have been identified that could cumulatively geotechnical resources, no further cumulative effects analysis is warranted.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

No irreversible or irretrievable commitments of resources were identified in association with this geotechnical analysis.

3M. AIR QUALITY

INTRODUCTION

Neither public nor agency scoping identified potential effects to air quality as a key issue within this analysis. The two action alternatives include the same level of selective tree removal but each has a varying degree of ground disturbance due to the inclusion of snowmaking under Alternative 2.

SCOPE OF THE ANALYSIS

The air quality analysis for this analysis focuses on the Snowbowl SUP area (NFS lands), the adjacent base area, and a proximate Class I airshed.[426]

FEDERAL AND STATE AIR QUALITY REGULATIONS

FEDERAL

The Clean Air Act (CAA) was enacted in 1955, but it contained few requirements for reducing air pollutant emissions. It was amended numerous times from 1963 through 1990 to address reductions in vehicular and stationary source emissions and to establish national air pollution concentration limits. It also established several programs, including: the National Ambient Air Quality Standards (NAAQS), which limited air concentrations to protect public health and welfare; the New Source Performance Standards, which set emission standards for major sources; and the State Implementation Plan (SIP) procedures, which were designed to bring areas that exceeded NAAQS levels (non-attainment areas) to within the standards. Table 3M-1 lists the state and Federal Ambient Air Quality Standards.

Table 3M-1
State and Federal Ambient Air Quality Standards

Pollutant	Averaging Period	Primary Standard	Secondary Standard
Carbon Monoxide (ppm)	1 hour 8 hour	35 9	-- --
Nitrogen Dioxide (NO2) (ppm)	Annual	0.05	0.05
Particulate Matter (PM10) (micrograms/m3)	24 hour Annual	150 50	150 50
Ozone (ppm)	1 hour	0.12	0.12
Sulfur Dioxide (SO2) (ppm)	3 hour 24 hour Annual	-- 365 (0.14) 80 (0.03)	1300 (0.5) -- --
Lead (Pb) (micrograms/m3)	Calendar Quarter	1.5	1.5

Source: ADEQ 2003

[426] The nearest Class I airshed is Sycamore Canyon Wilderness. The Kachina Peaks Wilderness is not classified as a Class I airshed, though it is treated as if it were.

In its amended form, the CAA designates two separate air quality areas receiving differing levels of protection. Class I areas generally include National Parks, Federally-designated Wilderness areas that are in excess of 5,000 acres and which were created prior to 1977,[427] National Monuments, National Seashores, and other areas of special national or regional value. Class I designation warrants the highest level of protection afforded to an area. Class II designation typically applies to all non-Class I areas.

Class I and II areas are either designated as attainment, non-attainment, or unclassifiable areas. Unclassifiable designations apply where pollution is not anticipated to exceed national standards and where insufficient information is available to either substantiate or reject this assumption. Unclassified areas generally have little, if any, industrial development and comparatively sparse populations. The low likelihood of air quality problems makes these areas a lower priority for expensive monitoring programs.

In addition to the NAAQS discussed above, the EPA has created regulations to protect and enhance air quality. The Prevention of Significant Deterioration (PSD) regulations are intended to help maintain good air quality in areas that attain the national standards and to provide special protections for national parks, Federally-designated wildernesses areas, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic, or historical value.[428] These regulations stipulate that new sources must not cause a decline in ambient air quality and must use best available control technology to limit emissions.

PSD permits are required for "major emitting facilities" which emit, or have the potential to emit, 100 tons or more per year of any air pollutant.[429] EPA regulations specifically list the sources that are considered "major emitting facilities" – this list does not include ski areas.[430] However, the regulations note that the term "major emitting facilities" also includes "any other source with the potential to emit two hundred and fifty tons per year or more of any air pollutant."[431] A PSD permit is not required for Snowbowl because the ski area does not have the potential to emit over 250 tons of any regulated air pollutant.

In an effort to eliminate or minimize the severity and number of violations of the NAAQS and to achieve expeditious attainment of these standards, the EPA promulgated the Conformity Rule in 1993. Conformity regulations apply to Federal actions and environmental analyses in non-attainment areas completed after March 15, 1994. The conformity regulations do not apply to Snowbowl area because it is classified as an area in attainment for all criteria pollutants.

VISIBILITY

Visibility is the maximum distance that an object can be perceived against the background sky; it also includes the clarity with which the form and texture of objects can be seen. Visibility impairment in Arizona is most often related to fine particulates in

[427] The Kachina Peaks Wilderness was designated by Congress in 1984.
[428] 42 USC 7470-7479, 1997
[429] 42 USC 7475(a) and 7479(1), 1997
[430] 42 USC 7479(1), 1997
[431] 42 USC 7479(1), 1997

the atmosphere; these particulates either scatter or absorb light, obscuring vision. The most common anthropogenic sources for these particulates are vehicular emissions, fugitive dust from unpaved roads, and wildfires. Topographic features, wind patterns, and humidity are all related to effects on visibility.

Prevention of visibility impairment to Class I areas is required by the EPA's CAA implementing regulations.[432] The Forest Service has also created visibility standards called Limits of Acceptable Change to determine sensitive receptors within the Wilderness and how much air pollution is acceptable. As previously stated, the Kachina Peaks Wilderness is not technically classified as a Class I airshed, though it is treated as if it were. The Kachina Peaks Wilderness is the only protected airshed proximate to the Snowbowl area which has relevance to this analysis.

STATE

The EPA retains oversight authority for air quality but has delegated enforcement of the CAA to the states. In Arizona, the Air Quality Division of the Arizona Department of Environmental Quality (ADEQ) acts as the lead agency. The state is required to develop and administer air pollution prevention and control programs; state standards must be either the same as, or more stringent than, Federal CAA standards. Table 3M-1 lists the State and Federal Ambient Air Quality Standards.

EXISTING CONDITIONS

CLIMATE AND METEOROLOGY

Snowbowl has a climate monitoring station at the Hart Prairie Lodge, which is at 9,300 feet in elevation. This station shows average total snowfall over a period of 22 years (1981/82 season through 2002/03 season) to be 232.5 inches per year, with a maximum of 460 inches during the 1992/93 season and a minimum of 76 inches during the 1983/84 season.

The average daily temperature for the past three winter operating seasons (November through March of 2000/01, 2001/02, and 2002/03) has been 27.6, 29.9, and 30.1 degrees Fahrenheit, respectively. The average low temperatures for the same time periods were 24.7, 22.2, and 23.1 degrees Fahrenheit, respectively. With moisture in the air, Snowbowl has sufficient temperatures to produce and maintain snow on the mountain throughout the winter operating season.

Due to its desert locale, humidity is low and diurnal temperature fluctuations are high at Snowbowl. Prevailing winds are generally from the northwest, and the region receives the majority of its winter precipitation from Pacific storms. Average winter wind speed, (based on 12 winter months of data) measured at the Hart Prairie Lodge, is 3.4 mph, with gusts up to 43 mph.

ONGOING OPERATIONS

Snowbowl maintains one air quality permit through the state of Arizona; permit number 1000934 is a class 2 permit for a Detroit V92 diesel engine with turbo that provides

[432] 40 CFR 51.300-51.307, 1999

auxiliary power for the Agassiz Lift at Snowbowl. Auxiliary power is for backup in the event of an electric power outage only. As a result this engine operates less than 25 hours per year on average. This is also the case for the auxiliary power sources at all other lifts at Snowbowl; which each run less than 25 hours per year.

Emergency generators used to provide backup power to lifts could produce occasional, short-term emissions. Some fugitive dust may result from the operation of ski area vehicles on the mountain road network during the summer for ski area maintenance; however, this is minor because of the limited extent of road use. These potential sources are not considered to substantially contribute to air quality related values and are therefore not discussed further in this analysis.

Most day-to-day pollutant sources in the Snowbowl area are assumed to result from mobile sources rather than stationary point sources. Potential mobile sources of air pollution include automobiles, trucks, buses, snowmobiles, slope grooming equipment, and emergency power generators. Of these, only automobiles are thought to contribute to substantial pollutant emissions. Automobile emissions, like other mobile sources, can occur over a broad geographic area. The effects of automobile emissions are likewise dispersed over an equally large area, and dispersal is highly dependent on topographic and climatic conditions.

SUMMARY

Air quality in the project area meets both Arizona air quality regulations and Federal CAA standards, and Snowbowl is currently in attainment with the state and Federal regulations for all six criteria pollutants.

ENVIRONMENTAL CONSEQUENCES

Issue:

Snowplay activities at Snowbowl could increase vehicular traffic and may negatively impact air quality in the region.

Indicator:

Compliance with Local, State, and Federal Regulations Regarding Air Quality.

Air quality effects of greatest concern as related to implementation of the Proposed Action are fugitive dust during construction, vehicular emissions as a result of skier and snowplay visitation, and smoke emissions from burning slash.

DIRECT AND INDIRECT EFFECTS

Alternative 1 – No Action

Under the No Action alternative, no new construction of trails or lifts would occur nor would the installation of snowmaking infrastructure occur. The area would maintain its permit for the auxiliary diesel engine and would likely continue to emit for short durations over the course of the winter, as disclosed above. No change in fugitive dust from traffic on dirt roads would be anticipated because no additional up-mountain maintenance traffic would be expected. Neither snowmobile nor slope grooming equipment use would increase because no additional terrain would be serviced.

With the selection of Alternative 1, there would be no increase in visitation. There would also be no change in current trends to air quality in and around Snowbowl. The area would remain in attainment for all six criteria pollutants and the visibility of the Kachina Peaks Wilderness would remain unimpaired.

Alternative 2 – The Proposed Action

Under the Proposed Action, the CCC of the Snowbowl would increase from 1,880 to 2,825 guests-at-one-time. However, because the ski area is already servicing in excess of 3,400 guests on peak days, this would not constitute and increase in daily visitation. The proposed snowtubing facility would be developed to accommodate 600 tubers-at-one-time. The snowplay guests would be supported by the construction of a 400 space parking lot. The snowtubing facility is anticipated to receive average daily use of approximately 420 guests; with peak day visitation approaching 1,680 visitors.[433] Assuming average vehicle occupancy of three persons per car this would equate to 143 and 560 additional vehicles on average and peak days respectively. Although the development of the proposed snowplay facility would result in a net increase in total vehicles at Snowbowl, it is implicit that a large portion of these vehicles are currently traveling the Snowbowl Road and to the ski area seeking snowplay opportunities.

Under existing conditions, average annual skier visitation is approximately 98,000 guests. At 2.5 people per vehicle, this equates to approximately 39,200 vehicles at Snowbowl each year. In ten years, at full build-out of the Proposed Action, visitation would increase to approximately 215,000 skiers and 42,000 snowplayers. Using a factor of 2.5 skiers per vehicle and three snowplayers per vehicle, this would equate to approximately 100,000 vehicles at Snowbowl each year.

As detailed in the Recreation section of this chapter, parking has recently been prohibited along the Snowbowl Road approaching the ski area. As a result, dispersed snowplay activities are effectively prohibited as well. On peak days during the 2002/03 ski season, as many as 300 to 500 vehicles per day arrived at the ski area in search of snowplay opportunities and were turned away due to lack of parking or overselling of tickets. As a result, it appears that many of the additional vehicles anticipated to result from the operation of the snowplay facility are accounted for in traffic numbers and ADEQ air quality monitoring. These snowplay seekers would not necessarily constitute a net increase in average daily traffic or result in substantial additional vehicular emissions in the area.

Other effects to air quality under Alternative 2 would be an increase in particulate matter during construction as fugitive dust escapes specific project construction areas and enters the atmosphere. Overall, Alternative 2 proposes approximately 245.4 acres of temporary and permanent ground disturbances. However, ground disturbing activities would be

[433] Refer to the Recreation section for additional detail pertaining to the proposed snowplay facility and estimated useage.

implemented over the course of several summers with total areas disturbed at a given time being relatively confined.

The temporary effects to air quality as a result of construction activities would be minimized by precipitation and/or the required watering of disturbance areas during construction. Additionally, areas of proposed disturbance would be reseeded and replanted promptly after the disturbance occurs to reduce the duration and extent of soil exposure. Refer to the mitigation measures listed in Table 2-2 for more information on these requirements.

Selection and implementation of proposed project elements in Alternative 2 would entail the removal of approximately 76.3 acres of permanent overstory vegetation. In areas where access is difficult, trees would be lopped and scattered. In more accessible areas of vegetation removal, merchantable timber volumes would be assessed prior to project implementation. It would then be removed and sold as required by the Forest Service. Prescribed burning of the remaining slash would involve hand or machine piling to insure the slash is burned in distinct piles rather than broadcast burning. Snowbowl would obtain all necessary burn permits from the Forest Service and ADEQ prior to any burning to ensure compliance with all local, state, and Federal regulations. Prescribed burning of slash would result in short-term, temporary increases to $PM_{2.5}$, PM_{10} in the vicinity of Snowbowl. Because winds are primarily from the northwest, smoke from the prescribed burning may affect visibility in the southeastern portion of the Kachina Peaks Wilderness; however, the effects would be short-term and temporary.

As a result of implementation of Alternative 2, Snowbowl would remain in attainment for all six criteria pollutants. It would also maintain the integrity of the visibility in the nearby Kachina Peaks Wilderness. Snowbowl would maintain compliance with all local, state, and Federal air quality regulations.

Alternative 3

Under Alternative 3, the CCC of the Snowbowl would increase from 1,880 to 2,825 guests-at-one-time. However, because the ski area is already servicing in excess of 3,400 guests on peak days, this would not constitute and increase in daily visitation. The proposed snowtubing facility would not be developed. As stated previously, parking has recently been prohibited along the Snowbowl Road approaching the ski area; as a result, dispersed snowplay is also prohibited. Many vehicles have approached Snowbowl seeking snowplay opportunities and have returned home without finding access to these activities. As a result of Alternative 3, this level of dispersed snowplay traffic would likely continue and would likely not result in an increase in average daily traffic or result in additional vehicular emissions in the area.

Because Alternative 3 does not include the installation of any snowmaking infrastructure, the overall amount of temporary and permanent ground disturbance is reduced to approximately 131.4 acres. As stated previously, the temporary effects to air quality as a result of construction would be minimized by precipitation and/or watering of disturbance areas during construction. Additionally, areas proposed for disturbance would be reseeded and replanted promptly after the disturbance occurs to reduce the duration and extent of soil exposure. Refer to the mitigation measures listed in Table 2-2 for more information on these requirements.

Selection and implementation of proposed project elements in Alternative 3 would entail the removal of approximately 64.4 acres of permanent overstory vegetation. As disclosed under Alternative 2, in areas with difficult access, trees would be lopped and scattered. In more accessible areas, merchantable timber would assessed prior to project implementation. It would then be removed and sold as required by the Forest Service. Prescribed burning of the remaining slash would involve hand or machine piling to insure the slash is burned in distinct piles rather than broadcast burning. Snowbowl would obtain all necessary burn permits from the Forest Service and ADEQ prior to any burning to ensure compliance with all local, state, and Federal regulations. As stated previously, prescribed burning of slash would result in short-term, temporary increases to $PM_{2.5}$, PM_{10} in the vicinity of Snowbowl. Because winds are primarily from the northwest, smoke from the prescribed burning may affect visibility in the southeastern portion of the Kachina Peaks Wilderness; however, the effects would be short-term and temporary.

As a result of implementation of Alternative 3, Snowbowl would remain in attainment for all six criteria pollutants with a net reduction of direct and indirect effects as compared to those disclosed under the Proposed Action. It would also maintain the integrity of the visibility in the nearby Kachina Peaks Wilderness. Snowbowl would maintain compliance with all local, state, and Federal air quality regulations.

CUMULATIVE EFFECTS

Scope of Analysis

Temporal Bounds

The temporal bounds of the cumulative effects analysis for air resources extends from the initial development of the Snowbowl in 1938 into the foreseeable future for which this and other projects can be expected to continue in and around the Snowbowl SUP area.

Spatial Bounds

The physical extent of this cumulative effects analysis comprises the Snowbowl SUP area, the surrounding Kachina Peaks Wilderness area, approximately 600 acres in the lower Hart Prairie area, and 9,100 acres in the lower south and west slopes of the Peaks.

Past, Present, and Reasonably Foreseeable projects relevant to a discussion of Cumulative Effects

No past activities having potential to cumulatively affect air quality resources were identified for this analysis. Present and reasonably foreseeable projects with potential to cumulatively affect air quality include:

1. Bebbs Willow Restoration Project
2. Fort Valley Restoration Project

Appendix C includes the full list of past, present and reasonably foreseeable future actions analyzed in this document, as well as background information on each of them.

Alternative 1 – No Action

The past, present and reasonably foreseeable actions identified above will not dramatically affect the air quality of the Peaks region. Activities in the vicinity of the project area that are likely to contribute to airborne particulates and visibility impairment in the analysis area include wildfires and other prescribed burn operations conducted in the area. Construction and prescribed burns are anticipated to be short-term and relatively small in scope. The tree thinning/prescribed burning projects listed above will consist of 9,700 acres of such activity, and remaining amounts of timber not removed and sold as required by the Forest Service will be transferred by hand and/or machine into distinct piles to be burned. Prescribed burning of slash will result in short-term, temporary increases to $PM_{2.5}$, PM_{10} in the vicinity of lower Hart Prairie and the lower south and west slopes of the Peaks.

Alternative 2 – The Proposed Action

The Proposed Action would result in 76.3 acres of permanent overstory vegetation removal within the Snowbowl SUP area, and remaining amounts of timber not removed and sold as required by the Forest Service will be transferred by hand and/or into distinct piles to be burned. The 76.3 acres of vegetation removal combined with the 9,700 acres of present and reasonably foreseeable projects within the vicinity would possibly result in the general treatment of approximately 9,776 acres of Forest. The prescribed burning of slash would have the same effect as stated in Alternative 1.

Alternative 3

Alternative 3 would result in 64.4 acres of permanent overstory vegetation removal within the Snowbowl SUP area. The 64.4 acres of vegetation removal combined with the 9,700 acres of present and reasonably foreseeable projects within the vicinity would possibly result in the general treatment of approximately 9,764 acres of Forest. The prescribed burning of slash would have the same effect as stated for Alternatives 1 and 2.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Temporary, reversible reductions in air quality would be experienced in the area as a result of construction activities. Although these impacts are irretrievable, they would only be anticipated to occur for a short duration.

3N. ENVIRONMENTAL JUSTICE

EXECUTIVE ORDER 12898

Executive Order (EO 12898), "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,"[434] provides that "each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." EO 12898 makes it clear that its provisions apply fully to programs involving Native Americans.

In the memorandum to heads of departments and agencies that accompanied EO 12898,[435] President Clinton specifically recognized the importance of the procedures under NEPA for identifying and addressing environmental justice concerns. The memorandum particularly emphasizes the importance of NEPA's public participation process, directing that "each Federal agency shall provide opportunities for community input in the NEPA process." Agencies are further directed to "identify potential effects and mitigation measures in consultation with affected communities, and improve the accessibility of meetings, crucial documents, and notices."

The CEQ has oversight of the Federal government's compliance with EO 12898 and NEPA. The CEQ, in consultation with the EPA and other affected agencies, has developed guidance[436] to further assist Federal agencies with their NEPA procedures so that environmental justice concerns are effectively identified and addressed. The guidance reflects a general consensus based on Federal agencies' experience and understanding of the issues presented. The guidance is meant to be applied with flexibility, and its terms may be considered a point of departure rather than conclusive direction in applying the terms of EO 12898.

Environmental justice issues may arise at any phase within the NEPA process and agencies should consider these issues at each step of the process, as appropriate. Environmental justice encompasses a broad range of impacts covered by NEPA. Therefore, environmental justice concerns may arise from impacts on the natural and physical environment, such as human health or ecological impacts on minority populations, low-income populations, and Native Americans, or from related social or economic impacts.

The CEQ provides no standard formula for identifying or addressing environmental justice issues. However, agencies should recognize that the question of whether agency action raises environmental justice issues is highly sensitive to the history or

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[434] 59 Federal Register 7629, 1994

[435] Memorandum form the President to the Heads of Departments and Agencies. Comprehensive Presidential Documents No. 279 (February 11, 1994)

[436] CEQ 1997

circumstances of a particular community or population, the particular type of environmental or human health impact, and the nature of the proposal itself. In addition, neither EO 12898 nor CEQ guidance prescribes any specific format for examining environmental justice, such as designating a specific chapter or section in a NEPA document. Agencies are encouraged to integrate analyses of environmental justice concerns in an appropriate manner so as to be clear, concise, and comprehensible within the general format suggested in 40 CFR 1502.10.

Under NEPA, the identification of a disproportionately high and adverse human health or environmental effect on low-income population, minority population, or Native Americans does not preclude a proposed agency action from going forward, nor does it necessarily compel a conclusion that a proposed action is environmentally unsatisfactory.

HUMAN HEALTH EFFECTS

When determining whether human health effects are disproportionately high or adverse, agencies are to consider the following three factors to the extent practicable:

1. Whether the health effects, which may be measured in risks and rates, are significant, or above generally accepted norm.

2. Whether the risk or rate of hazard of exposure by a minority population, low-income population, or Native Americans to an environmental hazard is significant and appreciably exceeds or is likely to appreciably exceed the risk or rate to the general population or other appropriate comparison group.

3. Whether health effects occur in a minority population, low-income population, or Native Americans affected by cumulative or multiple adverse exposures from environmental hazards.

ENVIRONMENTAL EFFECTS

When determining whether environmental effects are disproportionately high and adverse, agencies are to consider the following three factors to the extent practicable:

1. Whether this is or will be an impact on the natural or physical environment that significantly and adversely affects a minority population, low-income population, or Native Americans.

2. Whether environmental effects are significant and are or may be having an adverse impact on minority populations, low-income populations, or Native Americans that appreciably exceeds or is likely to appreciably exceed those on the general population or other appropriate comparison group.

3. Whether the environmental effects occur or would occur in a minority population, low-income population, or Native Americans affected by cumulative or multiple adverse exposures from environmental hazards.

U.S. DEPARTMENT OF AGRICULTURE DEPARTMENTAL REGULATIONS

USDA Departmental Regulation #5600-2[437] provides direction to agencies for integrating environmental justice considerations into USDA programs and activities in compliance with EO 12898. This direction is a key element of the USDA's environmental justice implementation strategy. The USDA goals in implementing EO 12898 are as follows:

1. To incorporate environmental justice considerations into USDA programs and activities and to address environmental justice across mission areas.
2. To identify, prevent, and/or mitigate, to the greatest extent practicable, disproportionately high and adverse human health or environmental effects of USDA programs and activities on minority and low-income populations.
3. To provide, to the greatest extent practicable, the opportunity for minority and low-income populations to participate in planning, analysis, and decision-making that affects their health or environment, including identification of program needs and designs.

According to this departmental regulation, an environmental justice issue arises where conduct or action may involve a disproportionately high and adverse environmental or human health effect on an identifiable low-income or minority population. The determination of whether a particular program or activity raises an environmental justice issue depends on an evaluation of the totality of the circumstances. In determining if an effect on a minority and/or low-income population is disproportionately high or adverse, agencies should consider whether the adverse effect is appreciably more severe or greater in magnitude than the adverse effect that will be suffered by the non-minority population and/or non-low-income population.

EXISTING CONDITIONS

DEMOGRAPHICS AND EMPLOYMENT

The racial distribution of Arizona, Coconino County, and Flagstaff is summarized in Table 3N-1. The population of Coconino County has a substantially higher percentage of minorities than either the State or the City of Flagstaff. American Indians comprised almost 27 percent of the overall County's population in both 1990 and 2000.

[437] USDA 1997

Table 3N-1
Racial Distribution of the Population[a]
Arizona, Coconino County, Flagstaff (1990, 2000)

		White		Black		American Indian, Eskimo or Aleut		Hispanic or Latino (of any race)	
		Number	% of Total	Number	% of Total	Number	% of Total	Number	% of Total
Arizona	1990	2,963,186	68.1%	110,524	2.5%	203,527	4.7%	688,338	15.8%
	2000	3,873,611	60.3%	158,873	2.5%	255,879	4.0%	1,295,617	20.2%
Coconino County	1990	61,836	58.2%	1,419	1.3%	28,233	26.6%	9,696	9.1%
	2000	73,381	56.9%	1,215	1.0%	33,161	25.7%	12,727	9.9%
Flagstaff	1990	36,519	69.1%	1,135	2.1%	4,210	8.0%	6,972	13.2%
	2000	41,214	67.1%	927	1.5%	5,284	8.6%	8,500	13.8%

[a] Data does not represent total population or every group accounted for in 1990 and 2000 census

TRIBAL CONSULTATION

The Forest Service initiated Tribal consultation in June 2002 with 13 Native American tribes which hold the San Francisco Peaks sacred. Tribal consultation concerning the Proposed Action was initiated in June, 2002 with a formal letter from the Forest Supervisor to 13 tribal leaders. Also in June, 2002, the District Ranger contacted by phone, tribal representatives from Cultural Preservation Offices of 13 affiliated tribes to discuss the Snowbowl proposal and suggest pre-proposal meetings. Phone contacts between the District Archaeologist and several tribal Cultural Preservation Officers (Hopi, Navajo, Hualapai, San Carlos Apache, Yavapai-Apache) were made during the months of June-December 2002. In addition, follow-up phone calls to interested tribes were made by the District Archaeologist to ensure receipt of letters. Overall, numerous phone calls and letters have been sent to tribes and the tribal public requesting input.

Two formal public meetings were held on the Hopi and Navajo Indian Reservations (Tuba City and Kykotsmovi) on December, 9, 2002. The emphasis of these two public meetings was to explain the Proposed Action to Tribal members and to elicit comment/concerns on behalf of individuals and the tribe.

For information regarding additional contacts made with tribal members, see Chapter 3.

ENVIRONMENTAL CONSEQUENCES

Alternative 1 – No Action

The tribes have objected to the Snowbowl's presence from the start due to their belief that any disturbance of the San Francisco Peaks is sacrilegious; as a result, the continued use of the 777-acre SUP area for developed recreation negatively impacts its sacred values. While the No Action Alternative would not change the current configuration of the Snowbowl and would cause no additional ground or vegetation disturbance to the area, the Hopi Tribal Council and other tribes remain in opposition to the Snowbowl's continued presence on the sacred San Francisco Peaks landscape.

Nonetheless, no environmental justice issues have been identified in direct relation to selection of Alternative 1, as per USDA Departmental Regulations #5600-2 that are specific to environmental justice. As such, no disproportionately high/adverse human health or environmental effects to low-income populations would result from selection of Alternative 1.

The reader is referred to Chapter 3, Section A for discussions of direct, indirect and cumulative effects to cultural values.

Alternatives 2 and 3

As with Alternative 1, no environmental justice issues have been identified in direct relation to selection of either Alternative 2 or 3, as per USDA Departmental Regulations #5600-2 that are specific to environmental justice. No disproportionately high/adverse human health or environmental effects to low-income populations have been identified in association with selection of either of the action alternatives.

Beyond the issues associated with scarring (i.e., ground disturbance on the Peaks) and the physical act of snowmaking (taking over the duties of *katsinas*) the tribes have expressed concern that trace levels of unregulated residual constituents within reclaimed water could negatively impact the spiritual and medicinal purity of resident flora on the Peaks. The Heritage and Cultural Resources section of this chapter indicates that from a cultural/spiritual perspective, direct and indirect impacts to the San Francisco Peaks (including historic and proposed ground disturbance, snowmaking, and use of reclaimed water, etc.) are unable to be mitigated. Nonetheless, in an attempt to reduce potential impacts, the action alternatives include the development of a 2,500 square foot Native American cultural and education center, which would be constructed in or near the Agassiz Lodge. This center would be available to the entire community and would also serve as an educational and interpretive service for guests. Additional mitigation measures that are designed to address potential impacts to the cultural and religious integrity of the Peaks are detailed in Table 2-2 – Mitigation Measures and BMPs.

The reader is referred to Chapter 3, Section A for discussions of direct, indirect and cumulative effects to cultural values.